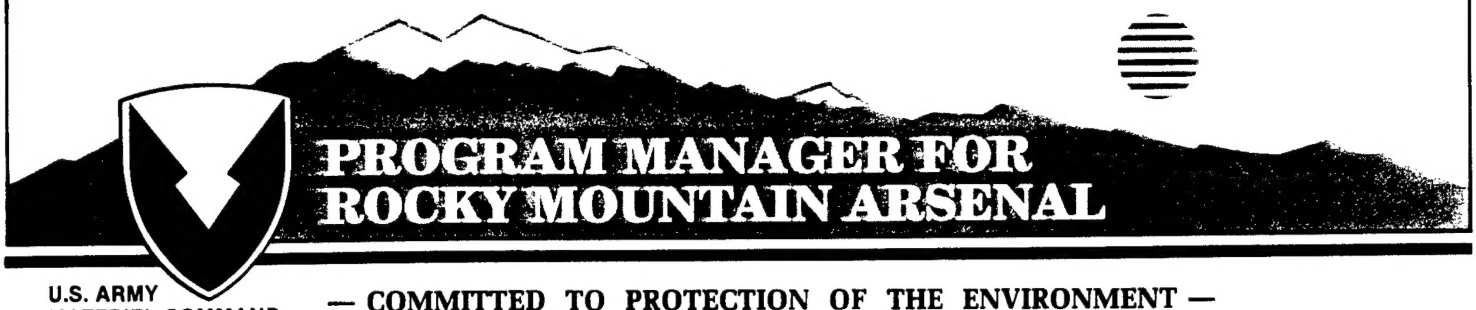

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COMPREHENSIVE AIR QUALITY AND METEOROLOGICAL MONITORING PROGRAM CONTRACT NO. DAAA15-88-D-0022 AIR QUALITY DATA ASSESSMENT REPORT FOR FY91 VOLUME III FINAL VERSION

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COMPREHENSIVE AIR QUALITY AND METEOROLOGICAL MONITORING PROGRAM
CONTRACT NO. DAAA15-88-D-0022
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VOLUME III
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Prepared by:
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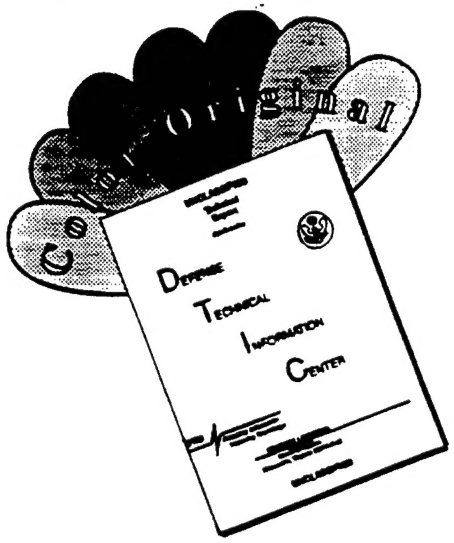

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13. ABSTRACT *(Maximum 200 words)*

THIS REPORT FOCUSES ON RESULTS OF THE CMP FOR FY91 AND INCLUDES ANALYSES AND COMPARISONS TO DATA FOR PRECEDING MONITORING PROGRAMS AT RMA AND FOR OTHER PROGRAMS WHICH RAN CONCURRENTLY. THE CMP FY91 DATA, IN CONJUNCTION WITH CMP FY88, FY89 AND FY90 DATA, BASIN F REMEDIAL MONITORING PROGRAM DATA, AND BASIN F POST-REMEDIAL IRA-F MONITORING PROGRAM DATA PROVIDE COMPREHENSIVE DATABASE FOR EVALUATING REMEDIAL PROGRESS RESULTING FROM THE BASIN F CLEANUP PROGRAM. ONE OBJECTIVE OF THIS REPORT IS TO PROVIDE AN ASSESSMENT OF THE COMBINED DATABASE IN THE CONTEXT OF REMEDIAL PROGRESS. (THIS REPORT CONSISTS OF FOUR VOLUMES AND TWO HIGH DENSITY DISKETTES CONTAINING THE MAJORITY OF THE TABLES PRESENTED IN VOLUME IV.)

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111TCE	1,1,1-Trichloroethane
112TCE	1, 1,2-Trichloroethane
ACGIH	American Council of Governmental Industrial Hygienists
ADI	Acceptable Daily Intake
Atrazine	2-chloro-4-ethylamino-6-isopropylamino-s-trianine
BCHPD	Bicycloheptadiene
CAQMMP	Comprehensive Air Quality and Meteorological Monitoring Program
C_6H_6	Benzene
CCl_4	Carbon Tetrachloride
CCM	Cubic Centimeters per Minute
CDH	Colorado Department of Health
CFM	Cubic Feet per Minute
CH_2Cl_2	Methylene Chloride
$CHCl_3$	Chloroform
Chlordane	1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-IH-indene
ClC_6H_5	Chlorobenzene
CMP FY90	Comprehensive Monitoring Program Fiscal Year 1990
CO	Carbon Monoxide
CRL	Certified Reporting Limit
CVAAS	Cold Vapor Atomic Absorption Spectroscopy
DBCP	Dibromochloropropane
DCLE11	1,1-Dichloroethane
DCLE12	1,2-Dichloroethane
DCPD	Dicyclopentadiene
DDD	Dichlorodiphenyidichloroethane
DIMP	Diisopropylmethyl phosphonate
DMB12	Dimethylbenzene
DMDS	Dimethyl Disulfide
DMMP	Dimethylmethyl phosphate
EPA	Environmental Protection Agency
ETC_6H_5	Ethylbenzene
GC/MS	Gas Chromatography/Mass Spectrometry
GC/ECD	Gas Chromatography/Electron Capture Detection
HEAST	Health Effects Assessment Summary Table
ICAP/ICP	Inductively Coupled Argon Plasma
IRA-F	Interim Response Action at Basin F
IRDMS	Installation Restoration Data Management System
IRIS	Integrated Risk Information System
ISC	Industrial Source Complex Dispersion Model

Malathion	0,0-dimethyl-s-(1,2-dicarboxyethyl) phosphorodithioate
MEC_6H_5	Toluene
MIBK	Methyl Isobutyl Ketone
MRI	Midwest Research Institute
MST	Mountain Standard Time
NAAQS	National Ambient Air Quality Standards
NATICH	National Air Toxics Information Clearinghouse
NIOSH	National Institute of Occupational Safety and Health
NNDMEA	N-Nitrosodimethylamine
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
O_3	Ozone
OCP	Organochlorine Pesticides
Parathion	Parathion ($C_{10}H_{14}NO_5PS$)
PMRMA	Program Manager Rocky Mountain Arsenal
PM-10/PM_{10}	Respirable Particulates less than 10 microns
PPDDE	Dichlorodiphenylethane
PPDDT	Dichlorodiphenyltrichloroethane
PSD	Prevention of Significant Deterioration
PUF	Polyurethane Foam
QA	Quality Assurance
QC	Quality Control
RBACs	Risk-Based Air Concentrations
RfCs	Reference Concentrations
RMA	Rocky Mountain Arsenal
SARA	Superfund Amendments and Reauthorization Act
SCCM	Standard Cubic Centimeters per Minute
SCFM	Standard Cubic Feet per Minute
SO_2	Sulfur Dioxide
Supona	2-chloro-1-(2,4-dichlorophenyl) vinyl diethyl phosphate
SVOC	Semi-Volatile Organic Compounds
T12DCE	Trans-1,2-Dichloroethene
TCLEE	Tetrachloroethene
TIC	Tentatively Identified Compound
TLV	Threshold limit value
tpy	tons per year
TRCLE	Trichloroethene
TSP	Total Suspended Particulates
UCRL	Upper Certified Reporting Limit
UNK	Unknown number
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USAEHA	U.S. Army Environmental Hygiene Agency

VOC	Volatile Organic Compounds
XYLENE	Xylene

5.0
CONTINUOUS AIR MONITORING PROGRAM

5.1 PROGRAM OVERVIEW

The Continuous Air Monitoring Program is described in Section 3.6. Measurements of criteria gaseous pollutants were taken continuously and recorded automatically on a data acquisition system. Summary tables of hourly averages and monthly composite listings of the sampling data for carbon monoxide (CO), ozone (O_3), sulfur dioxide (SO_2), nitric oxide (NO), nitrogen dioxide (NO_2), and nitrogen oxides (NO_x) are presented in Appendix H for the period October 1, 1990, through September 30, 1991 (FY91), and are summarized in this section.

The purpose of the gaseous monitoring program is to identify background concentrations of pollutants which play a role in possible future remediation activities. An assessment of these data yields additional insight into the atmospheric characteristics in and around the RMA site. This data assessment provides a general overview of the gaseous concentrations, as well as highlighting any anomalous values. The analysis also helps to identify meteorological and dispersion conditions which may affect air quality at RMA. For example, frequently occurring diurnal drainage winds with a nightly south to north air flow and a daily north to south air flow affect all six gas concentrations to some extent. Diurnal drainage winds are described in more detail in Section 2.2. Daytime photochemical activity primarily influences O_3 and NO_2. A summary of average and maximum concentrations measured during the FY91 program and additional analyses, are provided in this section.

A second major objective of the Continuous Air Monitoring Program is to compare the RMA concentrations with those of nearby regional, continuous air monitoring sites. These adjacent sites are administrated by the Colorado Department of Health (CDH) -Air Pollution Control Division. Locations of the CDH continuous air monitoring sampling sites are illustrated in Figure 5.1-1 and described in Table 5.1-1. Though there are several CDH monitoring sites located in and around the Denver metropolitan area, this report primarily compares the monitoring site at RMA to two of the CDH

monitoring sites. These sites include the CAMP site, located at 2105 Broadway in the downtown area of metropolitan Denver, and the Welby site, located at 78th and Steele Street in Commerce City. These sites were chosen because they generally represent the Denver metropolitan area and because they are relatively close in proximity to RMA and are used for comparative representativeness to RMA.

The CMP serves to establish baseline levels of ambient air quality for future assessments. Measured concentrations are compared with various meteorological data such as wind direction and atmospheric stability to identify migration patterns of gaseous pollutants from metropolitan Denver onto RMA. Baseline levels are also used to predict impacts of future remedial activity on the environment. The results shown here represent a complete year of data collection and an assessment of diurnal and annual cycles of each gas.

5.2 ANALYSIS OVERVIEW

A variety of tables and graphs were used to summarize the continuous air quality data. Mean values refer to daily averages and 1-hour maximum values refer to the highest 1-hour average values recorded daily. Comparisons of RMA data were made with National Ambient Air Quality Standards (NAAQS) and data from CDH sites. A further comparison was made with the data collected between May and September for CMP FY90 and the current CMP FY91 data. The analyses for carbon monoxide, ozone, and sulfur dioxide are presented individually in the following subsections. For nitric oxide, nitrogen dioxide, and nitrogen oxides, a combined analysis is provided because of the similarities in their chemical composition and concentration characteristics. Case studies were presented to examine the possible sources of some of the higher concentrations observed at RMA.

Ambient air quality data collected from October 1 through December 31, 1990, were invalidated. The data quality is unreliable because biweekly precision tests and quarterly audits were not conducted due to a lapse of the CMP service contract during this period.

5.3 CARBON MONOXIDE

The series of 1-hour and 8-hour maximum, minimum, and average carbon monoxide concentrations are illustrated with monthly graphs in Appendix I. During the sample collection period for FY91, there were a number of occasions where the daily maximum concentration was several times greater than the daily average. Also for this period, there were several occasions where the daily maximum and the daily mean concentrations were nearly the same value. Such instances usually occurred when persistent winds were blowing with a northerly or a southeasterly component. This flow allowed industrial pollutant matter to migrate away from RMA and not be detected.

Figure 5.3-1 presents RMA's continuous annual cycle of CO monthly mean values for the entire CMP FY89, FY90, and FY91 monitoring period (May 1989 to September 1991). Evident in this graph is the gradual increase in the monthly mean concentrations during the fall and winter seasons. This increase was primarily due to shallow and intense night surface inversions and very light winds which developed during these seasons. The high concentrations began to decrease with the approach of spring, warmer temperatures, and more frequently unstable atmospheric conditions.

Monthly summaries of the 1-hour and 8-hour averages are shown in Tables 5.3-1 and 5.3-2, respectively. The maximum observed 1-hour concentration was 4.3 ppm on February 2, 1991, between the hours of 2100 and 2200 MST. The maximum 8-hour concentration was 2.3 ppm on February 2, 1991, between the hours of 1600 and 2400 MST. The National and Colorado Ambient Air Quality Standards for the 1-hour and 8-hour averages, 35 ppm and 9 ppm, respectively, were never exceeded during the FY91 sample collection period at RMA. These concentrations represent 12.3 and 25.0 percent of the 1 and 8-hour standards, respectively.

In addition, an apparent diurnal cycle for FY91 is evident (Figure 5.3-2). As indicated in the FY89 and FY90 Assessment Reports, there are no major stationary sources of carbon monoxide in the RMA area. The high CO levels represent an influx of emissions from vehicles during the Denver metropolitan morning rush-hour (0600 to 1100 MST). There was also a smaller increase in CO concentrations during the hours of 2000 and 0200 MST. The data collected during FY91 also reflected a similar pattern. This

occurrence may have been the result of several factors, including the onset of the evening inversion, a shift in the wind direction, increased production from nearby power plants, and evening heating of homes, especially those with woodstoves.

Figures 5.3-3 and 5.3-4 compare the highest 1-hour and 8-hour carbon monoxide concentrations recorded at RMA to two CDH sites, Welby and CAMP, for the period from October 1990 to September 1991. These two graphs show that concentrations recorded at RMA were lower than the two CDH locations and significantly lower than the CAMP site for the fall and winter months.

5.4 OZONE

Table 5.4-1 presents a summary of monthly mean and maximum ozone concentrations at the RMA site for FY91. Figure 5.4-1 displays the monthly mean ozone values for the entire CMP period from May 1989 to September 1990. This graph also illustrates a very evident annual cycle for ozone. During the late spring and through the summer, generation of ozone increased, and peak concentrations were observed during July and August. Also seen in this graph is the evident minimum concentrations for ozone observed during the winter months.

A very distinct diurnal pattern for ozone is illustrated in Figure 5.4-2. Peak ozone concentrations occurred between the hours of 1300 and 1500 MST, when solar radiation intensity was at a maximum and played a major role in the formation of ozone. Ozone generation decreased after the peak hours and stabilized to minimum levels between 2400 and 0500 MST. Between the hours of 0500 and 0700 MST, ozone concentrations were further reduced. This reduction may be due to the increase in NO, NO_2, and NO_x concentrations associated with the beginning of the Denver metropolitan area rush-hour.

The highest ozone concentration, 0.099 ppm, was recorded on July 31, 1991, between the hours of 1400 and 1500 MST. This concentration represents 82 percent of the primary 1-hour National and Colorado Ambient Air Quality Standard of 0.120 ppm for ozone.

Figure 5.4-3 compares the highest 1-hour ozone concentrations recorded at RMA to the two CDH sites for the period from October 1989 to September 1990. Concentrations

at RMA were slightly higher than the CDH-measured concentrations during the fall and winter seasons.

Individual monthly graphs and tables are presented in Appendix H. These items contain daily maximum, minimum, and mean concentrations for each month.

5.5 SULFUR DIOXIDE

Tabular and graphical representation of the daily mean and maximum sulfur dioxide concentrations at the RMA site for FY91 are presented, by month, in Appendix H. Tables 5.5-1, 5.5-2 and 5.5-3 present monthly summaries of 1-hour, 3-hour, and 24-hour concentrations respectively. During this data collection period, there were numerous occasions where the daily maximum concentration was several times greater than the daily mean concentration, most likely reflecting the transport of concentrations onto RMA from metropolitan Denver SO_2 sources. There were also instances in which the daily maximum concentration was nearly the same as the daily mean concentration, reflecting periods when pollutants from metropolitan Denver were not migrating to RMA. There appears to have been no strong annual cycle for sulfur dioxide, as shown by the monthly mean values presented in Figure 5.5-1.

The diurnal pattern for sulfur dioxide at RMA is illustrated in Figure 5.5-2. A relative increase in SO_2 concentrations is evident between the hours of 0700 and 1100 MST. Sulfur dioxide emissions may be increased by an increase in power generations because of greater demand for electricity during these hours, by other industrial activity, and early morning inversions.

Maximum 3-hour and 24-hour SO_2 concentrations were less than six percent of the applicable National and Ambient Air Quality Standards of 0.5 and 0.14 ppm, respectively.

Figures 5.5-3 and 5.5-4 compare the highest 3-hour and 24-hour sulfur dioxide concentrations recorded at RMA to two CDH sites for the period from October 1990 to September 1991. The RMA site recorded lower values than the two CDH sites, and considerably lower values than the CAMP location.

Individual monthly graphs and tables are presented in Appendix H. These items contain daily maximum, minimum, and mean concentrations for each month.

5.6 NITRIC OXIDE, NITROGEN DIOXIDE, AND NITROGEN OXIDES

Tables and graphs of the series of daily mean concentrations for NO, NO_2, and NO_x on a monthly basis and presented in Appendix H. These graphs show an annual cycle for each parameter with peak concentrations most prevalent during the winter months of January and February. This cycle is further illustrated in Figures 5.6-1, 5.6-2, and 5.6-3, which display mean monthly concentrations for the complete CMP cumulative annual cycle from May 6, 1989, through September 30, 1991.

Monthly summaries for 1-hour average concentrations of NO, NO_2, and NO_x are given in Tables 5.6-1, 5.6-2 and 5.6-3, respectively. The National Ambient Air Quality Standard for NO_2 is 0.053 ppm and is an arithmetic mean. The mean for FY91, 0.014 ppm, represents 26 percent of the standard.

Since seasonal and diurnal trends of NO, NO_2, and NO_x are interrelated, an assessment of these three gases as a whole was made using NO_x as the indicator. The diurnal cycle for these gases illustrated a similar pattern with peak concentrations between the hours of 0700 and 0900 MST, which coincided with the Denver metropolitan area morning rush-hour. For the remainder of the day, these gases exhibited their lowest concentrations, although there is a slight rise again in the late evening hours, possibly from the reformation of the surface inversion. This cycle is depicted in Figure 5.6-4.

The individual maximum concentrations of NO_2 were recorded during the morning rush-hour, as the diurnal pattern portrays. Figure 5.6-5 compares the highest 24-hour nitrogen dioxide concentrations recorded at RMA to the CDH Welby site for the period. The RMA site recorded higher values than the CDH site. Several case studies are discussed in the next section showing the interaction of metropolitan Denver source emissions, meteorological conditions, and ambient concentrations measured at RMA.

Individual monthly graphs and tables are presented in Appendix H. The items contain daily maximum, minimum and mean concentrations for each day of each month.

5.7 REGIONAL EMISSION SOURCES IMPACTING RMA

Tables 5.7-1 through 5.7-3 provide listings of criteria pollutant emissions (carbon monoxide, sulfur dioxide, and nitrogen oxides) from major metropolitan Denver industrial sources. (Table 4.1-2 cited in Section 4.1.4, also provides a more detailed listing including many smaller sources.) Ozone (O_3) is not emitted directly from a source, as are other pollutants, but forms as a secondary pollutant. Its precursors are certain reactive hydrocarbons and nitrogen oxides (NO_x). Those sources listed in Tables 5.7-1 through 5.7-3 can therefore be considered as contributors to O_3 production.

In addition to stationary sources, automobile exhaust is a principal precursor of O_3 and, in the winter, produces 86 percent of the carbon monoxide (CO) measured in Denver and about 33 percent of the NO_x (CDH 1989). Both stationary and mobile emissions (primarily from vehicle traffic) jointly contribute to the ambient air quality conditions measured at RMA. Note that the RMA gaseous emissions are quite small compared to the significant major sources in the Denver area, as shown in Tables 5.7-1 through 5.7-3.

Figure 5.7-1 shows the distribution of stationary sources surrounding RMA (source locations are cross-referenced in Tables 5.7-1 through 5.7-3). Most of the sources are to the south and southwest of RMA, where the major vehicle activity also occurs. Monitoring results from the RMA station showed levels of O_3, CO, SO_2, and NO_x that were generally below metropolitan Denver monitoring values. However, when prevailing winds blew in the direction of RMA with a strong inversion and the associated brown cloud condition, external sources significantly impacted RMA.

A review of the air quality and meteorological data for RMA during FY91 indicates a number of episodes of probable pollution migration onto RMA. Case studies for TSP, PM-10, metals, and VOCs have been discussed in prior sections of this report. Emphasis in this section is placed on criteria gaseous pollutants. As noted, in the Tri-County area of Adams, Arapahoe, and Denver counties, there were a number of NO_x, CO, and SO_2 point sources and mobile sources that contributed to the RMA baseline air quality. By far, the poorest air quality days at RMA, as was the case with metropolitan Denver, were associated with the existence of intense ground-level inversions over the area and the subsequent development of the so-called brown cloud phenomenon. When this layer of

industrial pollution drifted over RMA, either directly or circuitously (after a wind shift), RMA recorded its highest levels for almost all pollutants measured. In the case of TSP, PM-10, metals, VOCs, and SVOCs, it was necessary to distinguish between potential local RMA sources and external sources. However, since emissions of criteria gaseous pollutants were minimal at RMA, a clear record of these incursions was provided by the meteorological and gaseous monitored data collected at RMA. Some examples are illustrated below.

5.7.1 February 2, 1991

During the evening of February 2, 1991, RMA recorded some of the highest yearly 1-hour concentrations of carbon monoxide (CO), nitric oxide (NO), nitrogen dioxide, and nitrogen oxides (NO_x). At 2200 MST on October 18, 1990, hourly concentrations of CO, NO, and NO_x were 4.3 ppm, 0.200 ppm, and 0.277 ppm, respectively. The 1-hour maximum for NO_2 recorded during this hour was 0.076 ppm and is one of the top 10 elevated maximums for the year. Table 5.7-4 presents pertinent data for this time period.

Meteorological conditions present during this episode are also shown in Table 5.7-4. It is evident that moderate temperatures dominated the Denver metropolitan area during this period. The positive temperature differences shown in Table 5.7-4 indicate the presence of an inversion. Also supporting the strength of this inversion were the light wind speeds of less than seven miles per hour (mph) and the atmospheric stability classifications of E to F, stable to extremely stable conditions. This inversion weakened for a few hours during midday on February 2, 1991, but was reinforced later that day in the early evening and did not break until mid-morning on February 2, 1991. This meant that there were no mechanisms to disperse the high concentrations of pollutants from the stagnant air mass encompassing the Denver metropolitan area and RMA. As a result, the concentrations of these pollutants continued to rise as recorded by the RMA monitoring site.

During this period, there was one noticeable episode of elevated NO_x and CO concentrations, one between February 2 and 3, 1991, from 2100 to 0300 MST. During this 7-hour period, the wind direction was mainly southerly, approximately 180 to

210 degrees. The wind speeds were very light, with stable conditions in the atmosphere (i.e., little or no mixing during the four hours prior to the episode). Possible causes for the increase in concentrations during this episode, in addition to the wind flow from metropolitan Denver in the direction of RMA, include: 1) the evening rush-hour from the Denver metropolitan area; 2) emissions from the nearby large sources such as Public Service Company - Cherokee Plant; 3) air traffic from Stapleton Airport; and 4) a composite of the above and other metropolitan industrial activity, trapped under a very intense inversion and drifting toward RMA.

5.7.2 August 31, 1991

At 0900 MST on August 31, 1991, the RMA recorded the highest yearly 1-hour concentrations of sulfur dioxide (SO_2), 0.046 ppm. This day was unique because the highest 1-hour concentration of SO_2 was recorded, but the other relevant air quality parameters of carbon monoxide (nitric oxide, nitrogen dioxide, and nitrogen oxides) were typical of the morning rush-hour pattern, showing some elevations but no obvious peak concentrations.

The air quality and meteorological conditions that were present during this episode are present in Table 5.7-5. From these data, it is noted that the concentrations of all air quality parameters were near normal up until 0900 MST. There were slight increases in NO, NO_2, and NO_x. During these early hours of the morning, winds were primarily from the south to southwest, with moderate wind speeds (6 to 8 mph) and a slightly stable atmosphere. Pollutant levels increased during the next several hours reaching peak concentrations at 0900 MST. Shortly thereafter, the inversion began to dissipate and all criteria pollutant levels decreased to normal baseline values. It is very likely that the source of the higher SO_2 concentrations at 0900 MST was the Public Service Company-Cherokee Plant. The wind direction for the previous hours, and for the hour of highest concentrations, was from the southwest, at approximately 220 degrees. This corresponds to the location where the plant would be directly upwind from RMA.

The peak SO_2 concentration at RMA was considerably below the short-term Colorado Ambient Air Quality Standard (0.50 ppm for 3 hours). However, this example demonstrates how closely ambient concentrations from a pollutant emission source were

determined by meteorological factors and, in particular, wind flow and atmospheric stability. Since RMA is not a major source of criteria pollutants, all peak concentrations measured at RMA were a reflection of the dispersion of emissions from upwind mobile and stationary sources. The CMP has documented numerous case studies ranging from typical morning surface inversions with modest impacts at RMA to intense winter surface inversion episodes and associated brown cloud conditions, where impacts on RMA have been severe. These impacts, controlled by meteorological conditions, included not only gaseous pollutants but other components of industrial pollution (such as TSP, PM-10, and metals) discussed elsewhere in this report. Still another consequence is the effect on ambient visibility which is discussed in the next section. As will be shown, there were strong similarities and interrelationships between all of these effects.

TABLE 5.1-1

RMA AND COLORADO DEPARTMENT OF HEALTH CONTINUOUS AIR QUALITY MONITORING SITES

Site Number	Site Name	Site Address	Reported Parameters						
			CO	O_3	SO_2	NO	NO_2	NO_x	PM
1	RMA	8th Avenue at D Street	X	X	X	X	X	X	X
2	Arvada	57th at Garrison							X
3	Albion	14th at Albion							X
4	Boulder	2320 Marine							X
5	Camp	2105 Broadway	X	X	X		X		X
6	Carriage	23rd and Julian	X	X					X
7	Englewood	3300 South Huron	X	X					X
8	Highland	8100 South University	X	X					X
9	Welby	78th at Steele	X	X	X		X		X

TABLE 5.3-1

SUMMARY OF CARBON MONOXIDE 1-HOUR AVERAGE VALUES IN PPM[1] OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)

	OCT	NOV	DEC	JAN	FEB	MAR
Mean	ND	ND	ND	0.63	0.68	0.31
Maximum	ND	ND	ND	3.28	4.32	1.50
2nd Highest Maximum	ND	ND	ND	3.14	3.38	1.36
Minimum	ND	ND	ND	0.10	0.10	0.10

	APR	MAY	JUN	JUL	AUG	SEP
Mean	0.38	0.23	0.24	0.35	0.40	0.30
Maximum	1.97	1.50	1.56	1.20	1.70	2.50
2nd Highest Maximum	1.53	1.12	1.55	1.16	1.70	2.0
Minimum	0.10	0.10	0.10	0.10	0.10	0.10
Mean for Entire Period	0.39					

[1] Federal and Colorado Ambient Air Quality Standard for maximum 1-hour average values is 35 ppm, not to be exceeded more than once a year.

Note: ND - no valid data collected.

TABLE 5.3-2

SUMMARY OF CARBON MONOXIDE 8-HOUR AVERAGE VALUES IN PPM[1] OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)

	OCT	NOV	DEC	JAN	FEB	MAR
Mean	ND	ND	ND	0.61	0.68	0.31
Maximum	ND	ND	ND	1.44	2.25	1.09
2nd Highest Maximum	ND	ND	ND	1.43	2.23	1.06
Minimum	ND	ND	ND	0.10	0.10	0.10

	APR	MAY	JUN	JUL	AUG	SEP
Mean	0.38	0.23	0.24	0.35	0.40	0.30
Maximum	0.84	0.77	0.91	0.78	1.0	1.0
2nd Highest Maximum	0.83	0.77	0.89	0.76	0.7	1.0
Minimum	0.20	0.10	0.10	0.10	0.10	0.10
Mean for Entire Period	0.39					

[1] Federal and Colorado Ambient Air Quality Standard for maximum 8-hour average values is 9 ppm, not to be exceeded more than once a year.

Note: ND - no valid data collected.

TABLE 5.4-1

SUMMARY OF OZONE 1-HOUR AVERAGE VALUES IN PPM[1]
OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)

	OCT	NOV	DEC	JAN	FEB	MAR
Mean	ND	ND	ND	0.024	0.020	0.033
Maximum	ND	ND	ND	0.062	0.052	0.059
2nd Highest Maximum	ND	ND	ND	0.060	0.051	0.059
Minimum	ND	ND	ND	0.001	0.001	0.001

	APR	MAY	JUN	JUL	AUG	SEP
Mean	0.037	0.040	0.039	0.038	0.035	0.029
Maximum	0.070	0.076	0.075	0.088	0.082	0.075
2nd Highest Maximum	0.068	0.076	0.075	0.084	0.082	0.067
Minimum	0.001	0.001	0.001	0.001	0.001	0.001
Mean for Entire Period	0.032					

[1] Federal and Colorado Ambient Air Quality Standard for maximum 1-hour average values is 0.120 ppm. The statistically estimated number of days with exceedances averaged over a 3-year period is not to be more than 1 per year.

Note: ND - no valid data collected.

TABLE 5.5-1

SUMMARY OF SULFUR DIOXIDE 1-HOUR AVERAGE VALUES IN PPM[1] OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)

	OCT	NOV	DEC	JAN	FEB	MAR
Mean	ND	ND	ND	0.002	0.002	0.002
Maximum	ND	ND	ND	0.01	0.032	0.018
2nd Highest Maximum	ND	ND	ND	0.009	0.028	0.015
Minimum	ND	ND	ND	0.001	0.001	0.001

	APR	MAY	JUN	JUL	AUG	SEP
Mean	0.001	0.001	0.002	0.002	0.002	0.002
Maximum	0.015	0.024	0.029	0.042	0.046	0.030
2nd Highest Maximum	0.014	0.016	0.027	0.036	0.020	0.028
Minimum	0.001	0.001	0.001	0.001	0.001	0.001
Mean for Entire Period	0.002					

[1] National and Colorado Ambient Air Quality Standard for annual arithmetic mean is 0.030 ppm. (There is no NAAQ 1-hour standard for SO_2.)

Note: ND - no valid data collected.

TABLE 5.5-2

SUMMARY OF SULFUR DIOXIDE 3-HOUR AVERAGE VALUES IN PPM[1] OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)

	OCT	NOV	DEC	JAN	FEB	MAR
Mean	ND	ND	ND	0.002	0.002	0.002
Maximum	ND	ND	ND	0.008	0.030	0.016
2nd Highest Maximum	ND	ND	ND	0.007	0.028	0.013
Minimum	ND	ND	ND	0.001	0.001	0.001

	APR	MAY	JUN	JUL	AUG	SEP
Mean	0.001	0.001	0.002	0.002	0.002	0.002
Maximum	0.010	0.015	0.023	0.028	0.017	0.014
2nd Highest Maximum	0.010	0.013	0.021	0.028	0.013	0.014
Minimum	0.001	0.001	0.001	0.001	0.001	0.001

Mean for Entire Period	0.002

[1] Federal and Colorado Ambient Air Quality Standard for maximum 3-hour average values is 0.500 ppm, not to be exceeded more than once per year.

Note: ND - no valid data collected.

TABLE 5.5-3

SUMMARY OF SULFUR DIOXIDE 24-HOUR AVERAGE VALUES IN PPM[1] OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)

	OCT	NOV	DEC	JAN	FEB	MAR
Mean	ND	ND	ND	0.002	0.002	0.002
Maximum	ND	ND	ND	0.002	0.007	0.004
2nd Highest Maximum	ND	ND	ND	0.002	0.004	0.003
Minimum	ND	ND	ND	0.001	0.001	0.001

	APR	MAY	JUN	JUL	AUG	SEP
Mean	0.001	0.001	0.002	0.002	0.002	0.002
Maximum	0.003	0.003	0.003	0.005	0.004	0.004
2nd Highest Maximum	0.002	0.003	0.002	0.003	0.003	0.004
Minimum	0.001	0.001	0.001	0.001	0.001	0.001
Mean for Entire Period	0.002					

[1] Federal and Colorado Ambient Air Quality Standard for maximum 24-hour average values is 0.140 ppm, not to be exceeded more than once per year.

Note: ND - no valid data collected.

TABLE 5.6-1

SUMMARY OF NITRIC OXIDE 1-HOUR AVERAGE VALUES IN PPM[1] OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)

	OCT	NOV	DEC	JAN	FEB	MAR
Mean	ND	ND	ND	0.015	0.017	0.004
Maximum	ND	ND	ND	0.168	0.200	0.067
2nd Highest Maximum	ND	ND	ND	0.114	0.164	0.050
Minimum	ND	ND	ND	0.001	0.001	0.001

	APR	MAY	JUN	JUL	AUG	SEP
Mean	0.002	0.002	0.002	0.003	0.005	0.007
Maximum	0.088	0.051	0.047	0.045	0.064	0.127
2nd Highest Maximum	0.065	0.031	0.029	0.041	0.049	0.096
Minimum	0.001	0.001	0.001	0.001	0.001	0.001
Mean for Entire Period	0.006					

Note: ND - no valid data collected.

TABLE 5.6-2

SUMMARY OF NITROGEN DIOXIDE 1-HOUR AVERAGE VALUES IN PPM[1] OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)

	OCT	NOV	DEC	JAN	FEB	MAR
Mean	ND	ND	ND	0.024	0.024	0.011
Maximum	ND	ND	ND	0.063	0.089	0.056
2nd Highest Maximum	ND	ND	ND	0.061	0.086	0.049
Minimum	ND	ND	ND	0.001	0.001	0.001

	APR	MAY	JUN	JUL	AUG	SEP
Mean	0.016	0.008	0.011	0.013	0.014	0.014
Maximum	0.058	0.059	0.061	0.053	0.057	0.072
2nd Highest Maximum	0.052	0.044	0.058	0.051	0.056	0.066
Minimum	0.001	0.001	0.001	0.001	0.001	0.001
Mean for Entire Period	0.014					

[1] Federal and Colorado Ambient Air Quality Standard for annual arithmetic mean is 0.053 ppm.

Note: ND - no valid data collected.

TABLE 5.6-3

SUMMARY OF NITROGEN OXIDES 1-HOUR AVERAGE VALUES IN PPM[1] OCTOBER 1, 1990 (0100 MST), THROUGH SEPTEMBER 30, 1991 (2400 MST)

	OCT	NOV	DEC	JAN	FEB	MAR
Mean	ND	ND	ND	0.040	0.041	0.016
Maximum	ND	ND	ND	0.232	0.212	0.109
2nd Highest Maximum	ND	ND	ND	0.170	0.243	0.098
Minimum	ND	ND	ND	0.001	0.001	0.001

	APR	MAY	JUN	JUL	AUG	SEP
Mean	0.015	0.011	0.014	0.016	0.021	0.022
Maximum	0.146	0.096	0.100	0.100	0.111	0.173
2nd Highest Maximum	0.113	0.087	0.078	0.086	0.102	0.144
Minimum	0.001	0.001	0.001	0.001	0.003	0.001
Mean for Entire Period	0.014					

Note: ND - no valid data collected.

TABLE 5.7-1

CARBON MONOXIDE (CO) SOURCES WITH EMISSIONS OF 100 TPY OR MORE

County	UTM/E	UTM/N	Map #	Plant Name	Emissions (tpy)	Percent Tri-County Total
Adams	504.7	4405.8	7	Colorado Refining Co.	788	25.6
Adams	503.0	4406.2	1	PSCO Cherokee Plant	571	18.6
Adams	504.5	4405.5	4	Conoco Inc.	272	8.8
Adams	501.0	4404.5	31	Cobitco Inc.	238	7.7
Adams	524.7	4400.5	3	Colorado Interstate Gas	165	5.4
Adams	503.8	4406.5	13	Metro Denver Sewage Disp.	160	5.2
Denver	499.8	4390.9	2	PSCO Arapahoe Plant	128	4.2
Adams	513.6	4408.3	30	RMA	7	0.3
TRI-COUNTY TOTALS					3077	75.8

Source: CDH 1992.

TABLE 5.7-2

SULFUR DIOXIDE (SO_2) SOURCES WITH EMISSIONS OF 40 TPY OR MORE

County	UTM/E	UTM/N	Map #	Plant Name	Emissions (tpy)	Percent Tri-County Total
Adams	503.0	4406.2	1	PSCO Cherokee Plant	12340[1]	61.1[1]
Denver	499.8	4390.9	2	PSCO Arapahoe Plant	4112[1]	20.4[1]
Adams	504.5	4405.5	4	Conoco, Inc.	2504[1]	12.4[1]
Adams	504.7	4405.8	7	Colorado Refining Co.	1041[1]	5.2[1]
Arapahoe	500.5	4391.5	26	Littleton/Englewood	262[2]	1.5[2]
Denver	500.6	4399.1	10	The Gates Rubber Co.	76[2]	0.4[2]
Adams	504.0	4405.0	27	Republic Paper Board Co.	54[2]	0.3[2]
Denver	503.5	4403.1	28	Ralston Purina Co.	51[2]	0.3[2]
Adams	513.6	4408.3	30	RMA	5	
TRI-COUNTY TOTALS					20200[1]	99.0[1]

Source:

[1] CDH 1992. Percent total based on top 4 emittors for 1991; other emission totals based on 1989 data for relative comparison.

[2] CDH 1990.

TABLE 5.7-3

NITROGEN OXIDES (NO_X) SOURCES WITH EMISSIONS OF 40 TPY OR MORE

County	UTM/E	UTM/N	Map #	Plant Name	Emissions (tpy)	Percent Tri-County Total
Adams	503.0	4406.2	1	PSCO Cherokee Plant	17025	59.1
Denver	499.8	4390.9	2	PSCO Arapahoe Plant	5629	19.5
Denver	502.9	4399.5	32	Presbyterian/St. Luke's Healthcare	763	2.6
Adams	524.7	4400.5	3	Colorado Interstate Gas	718	2.5
Adams	504.5	4405.5	4	Conoco Inc.	634	2.2
Adams	525.1	4414.8	5	Koch Hydrocarbon Co.	569	2.0
Adams	526.1	4399.8	6	Amoco Production Co. Wat.	409	1.4
Adams	504.7	4405.8	7	Colorado Refining Co.	365	1.3
Arapahoe	520.0	4395.6	9	U.S. Govt. Buckley ANGB	290	1.0
Denver	500.1	4400.4	25	PSCO Delgany Plant	285	1.0
Denver	500.6	4399.1	10	The Gates Rubber Co.	266	0.9
Denver	498.6	4398.4	11	PSCO Zuni Plant	213	0.7
Arapahoe	570.6	4384.2	12	Colorado Interstate Gas	145	0.5
Adams	516.0	4427.6	20	Panhandle East Pipeline	120	0.4
Adams	503.8	4406.5	13	Metro Denver Sewage Disp.	110	0.4

TABLE 5.7-3
(Concluded)

County	UTM/E	UTM/N	Map #	Plant Name	Emissions (tpy)	Percent Tri-County Total
Arapahoe	541.0	4394.0	18	Gulf Energy Development	96	0.3
Arapahoe	555.4	4388.0	15	Koch Hydrocarbon Co.	84	0.3
Adams	551.7	4414.8	19	Koch Hydrocarbon Co.	80	0.3
Adams	530.8	4414.9	21	Koch Hydrocarbon Co.	73	0.3
Adams	539.8	4409.2	23	Koch Hydrocarbon Co.	66	0.2
Adams	501.2	4406.4	24	ITT Continental Baking	47	0.2
Adams	555.4	4388.0	15	Koch Hydrocarbon Co.	42	0.1
Adams	513.6	4408.3	30	RMA	25	0.1
TRI-COUNTY TOTALS					28805	97.4

Source: CDH 1992.

TABLE 5.7-4

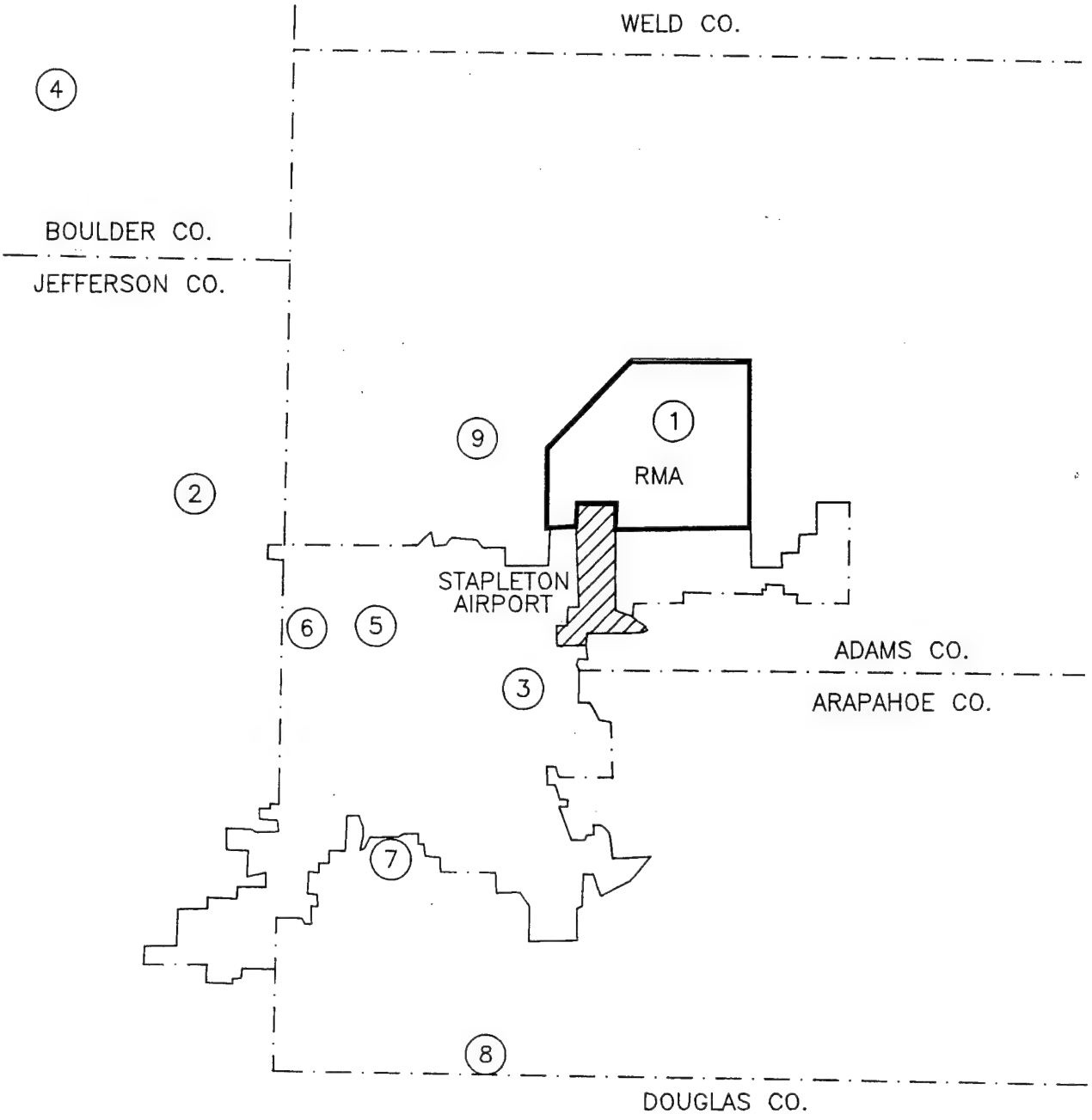
RELEVANT AIR QUALITY AND METEOROLOGICAL DATA

FEBRUARY 2, 1991

Date		HOUR	CO	SO2	NO	NO2	NOX	WIND SPEED	WIND DIR	TEMP 10M	TEMP DIFF	STAB CLASS
			ppm	ppb	ppb	ppb	ppb	mph	deg	deg F	10m-2m	
2	2	1200	0.96	1.00	29.08	36.11	66.00	5.13	205.10	51.87	0.06	B
2	2	1300	0.61	1.00	13.06	17.94	31.95	4.05	212.50	57.14	-0.26	A
2	2	1400	1.51	7.18	38.11	68.74	107.50	9.75	8.33	49.44	-0.21	D
2	2	1500	0.89	3.47	21.26	39.04	61.11	10.01	5.43	45.74	-0.22	D
2	2	1600	0.60	6.36	13.58	30.24	44.66	6.34	6.07	47.52	0.01	D
2	2	1700	0.76	9.55	10.09	40.98	51.87	3.29	54.37	48.20	0.57	F
2	2	1800	0.80	7.69	5.91	50.92	57.58	3.36	29.08	45.15	2.60	F
2	2	1900	0.69	4.73	5.80	44.62	51.24	2.27	28.95	43.81	1.57	F
2	2	2000	0.78	5.38	6.74	46.39	53.94	2.30	149.00	42.73	5.14	F
2	2	2100	3.26	6.94	144.90	73.50	218.80	6.89	180.20	40.05	9.24	D
2	2	2200	4.32	6.86	200.40	75.90	276.60	6.63	203.90	37.28	5.59	D
2	2	2300	3.38	5.68	155.30	69.98	225.70	8.36	209.00	33.91	4.36	D
2	2	2400	1.95	4.68	70.10	62.21	132.90	8.46	192.60	33.01	2.88	E
2	3	100	1.82	5.51	65.94	56.12	122.70	8.99	179.70	34.13	4.07	E
2	3	200	1.27	3.99	31.52	53.40	85.70	8.13	185.30	35.05	3.47	E
2	3	300	1.20	2.65	26.77	50.09	77.60	8.00	201.00	32.75	4.64	D
2	3	400	0.66	1.00	2.94	33.67	37.51	10.90	197.40	31.81	2.97	E
2	3	500	0.49	1.00	2.10	25.42	28.42	13.24	204.80	31.43	3.48	D
2	3	600	0.45	1.00	1.00	22.23	25.12	12.10	202.90	31.47	3.15	D
2	3	700	0.51	1.00	1.00	28.64	31.42	9.64	200.80	30.07	4.67	E
2	3	800	0.51	1.00	5.48	26.73	33.10	8.93	193.90	32.34	2.93	D
2	3	900	0.55	1.00	11.39	21.57	33.88	5.97	183.90	36.73	0.97	D
2	3	1000	0.68	1.00	19.73	27.58	48.15	8.15	203.90	41.88	0.18	D
2	3	1100	0.75	4.03	25.56	32.76	59.10	6.80	218.60	46.99	-0.04	D
2	3	1200	0.54	10.00	20.50	27.88	49.26	4.76	213.60	51.83	-0.33	B

TABLE 5.7-5
RELEVANT AIR QUALITY AND METEOROLOGICAL DATA
31-Aug-91

Date	HOUR	CO (ppm)	SO2 ppb	NO ppb	NO2 ppb	NOX ppb	WIND SPEED mph	WIND DIR deg	TEMP 10M deg F	TEMP DIFF 10m-2m	STAB CLASS
8 31	100	0.30	1.00	2.57	14.88	18.46	5.35	193.80	64.29	4.29	D
8 31	200	0.27	1.00	2.51	15.47	18.94	5.60	154.50	62.60	8.31	D
8 31	300	0.10	1.00	2.45	10.98	14.31	8.10	145.80	59.98	6.25	E
8 31	400	0.10	1.00	2.13	10.77	13.85	6.11	167.40	57.89	4.66	E
8 31	500	0.10	1.00	2.26	13.04	16.41	4.61	182.10	57.52	5.11	E
8 31	600	0.10	1.00	2.82	13.42	17.27	6.18	176.60	56.61	4.98	E
8 31	700	0.44	1.00	11.52	20.68	33.24	5.28	180.00	57.30	0.44	E
8 31	800	0.44	4.60	11.10	21.15	33.25	6.85	214.20	62.22	-0.22	C
8 31	900	0.46	45.81	48.47	42.54	92.10	4.53	229.80	66.90	-0.40	C
8 31	1000	0.37	6.57	9.06	20.96	31.03	4.12	197.30	71.00	-0.73	A
8 31	1100	0.23	1.00	3.61	7.68	12.33	4.50	148.90	74.50	-0.81	A
8 31	1200	0.10	1.00	2.73	2.18	5.85	8.42	134.20	76.30	-0.73	A
8 31	1300	0.10	1.00	2.73	1.00	5.50	9.22	128.30	77.40	-0.81	C
8 31	1400	0.10	1.00	2.82	1.00	5.47	10.62	138.90	78.60	-0.86	B
8 31	1500	0.10	1.00	3.06	1.00	5.58	9.36	148.40	79.70	-0.70	C
8 31	1600	0.10	1.00	3.34	1.00	5.78	10.03	144.50	79.70	-0.38	C
8 31	1700	0.10	1.00	3.37	1.00	5.75	12.78	137.70	78.90	0.18	D
8 31	1800	0.10	1.00	3.15	1.00	5.64	11.27	136.10	76.70	0.89	D
8 31	1900	0.10	1.00	2.62	6.03	9.70	11.26	135.70	72.60	1.70	D
8 31	2000	0.10	1.00	2.68	3.43	7.21	11.45	140.90	68.25	1.65	D
8 31	2100	0.10	1.00	2.70	2.64	6.30	15.26	150.90	65.60	1.20	D
8 31	2200	0.10	1.00	2.42	2.96	6.49	15.28	161.10	65.98	1.22	D
8 31	2300	0.10	1.00	2.25	4.74	7.99	16.27	170.60	65.61	0.96	D
8 31	2400	0.10	1.00	2.22	3.47	6.79	17.48	163.50	64.55	0.98	D

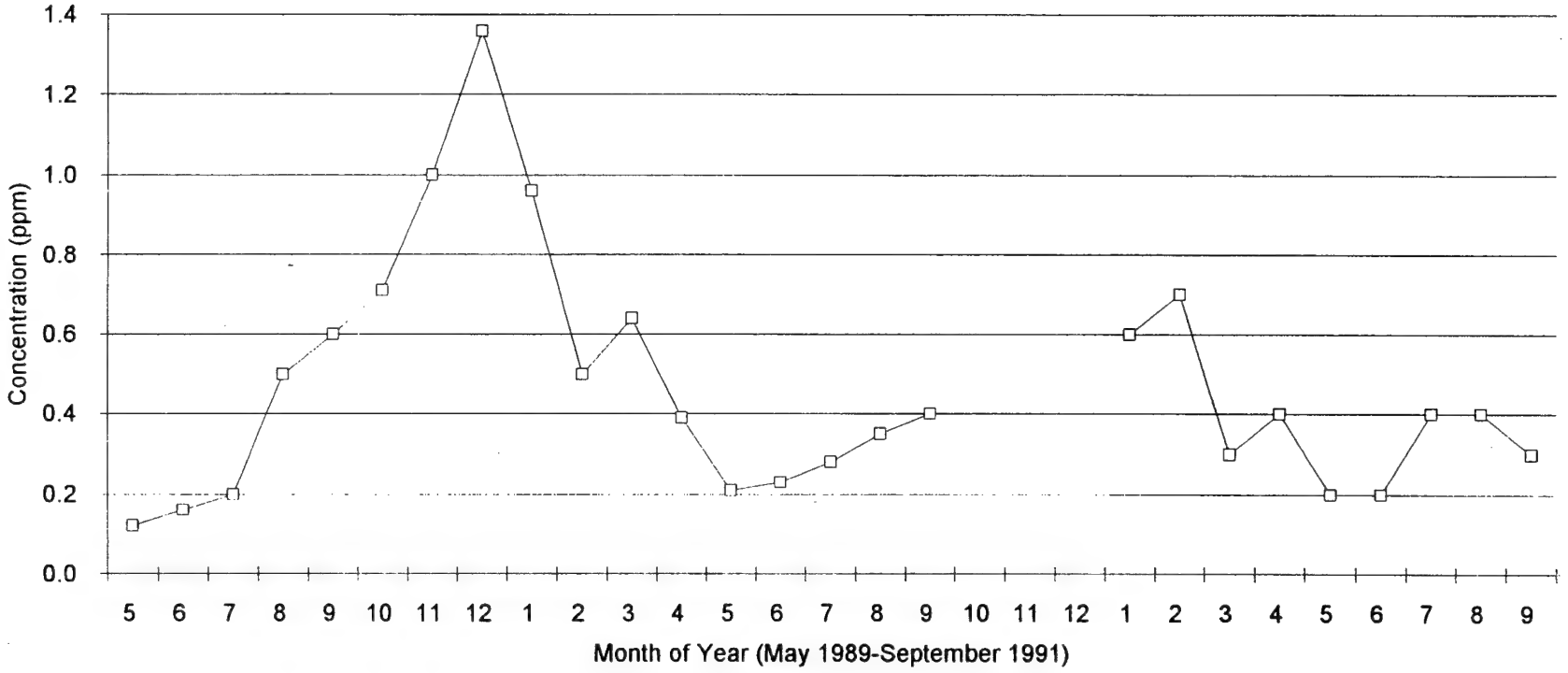


Job No. :	22787E
Prepared by :	M.R.M.
Date :	7/1/92

RMA AND COLORADO DEPARTMENT OF HEALTH CONTINUOUS AIR QUALITY MONITORING SITES

2787E001

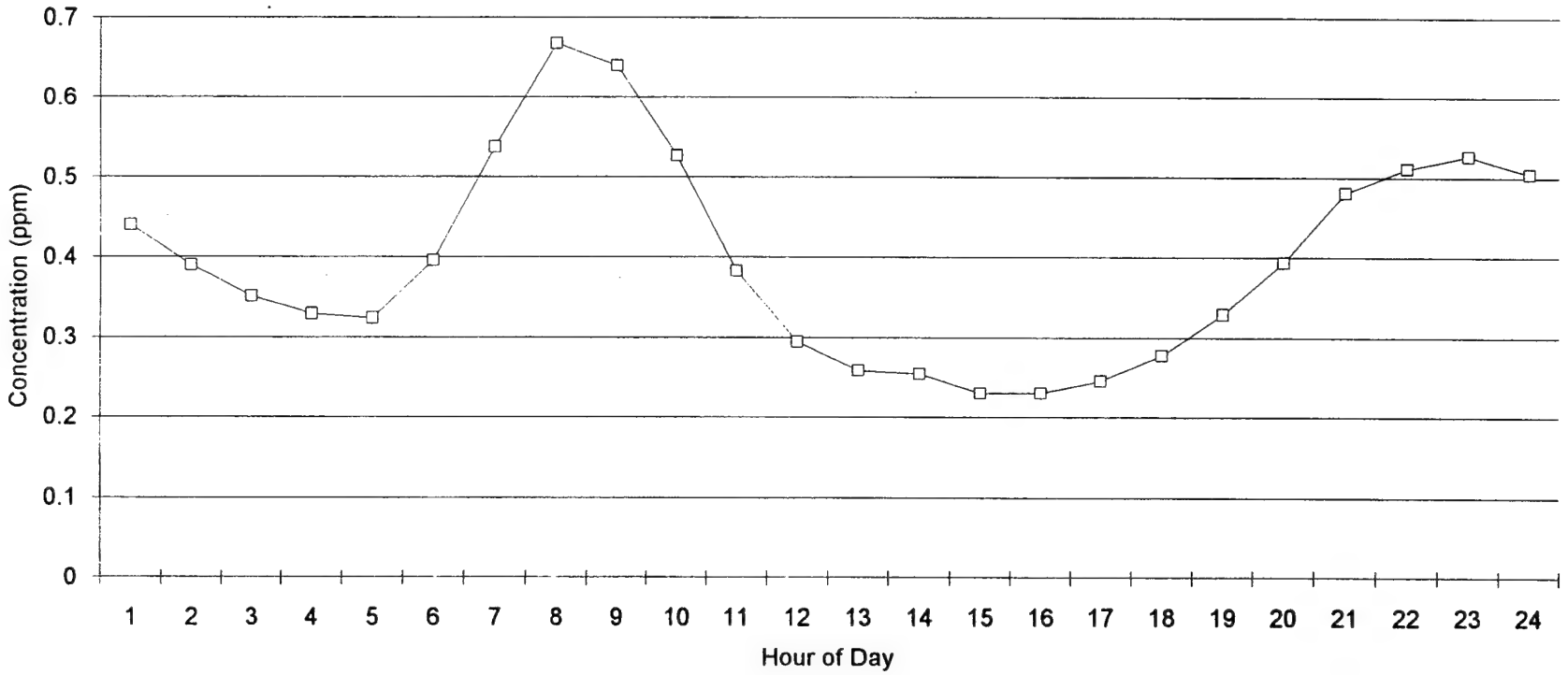
FIG. 5.1–1



Job No. :	22923E
Prepared by :	T.G.D.
Date :	7/17/92

MONTHLY MEAN FOR CARBON MONOXIDE RMA CMP FY91

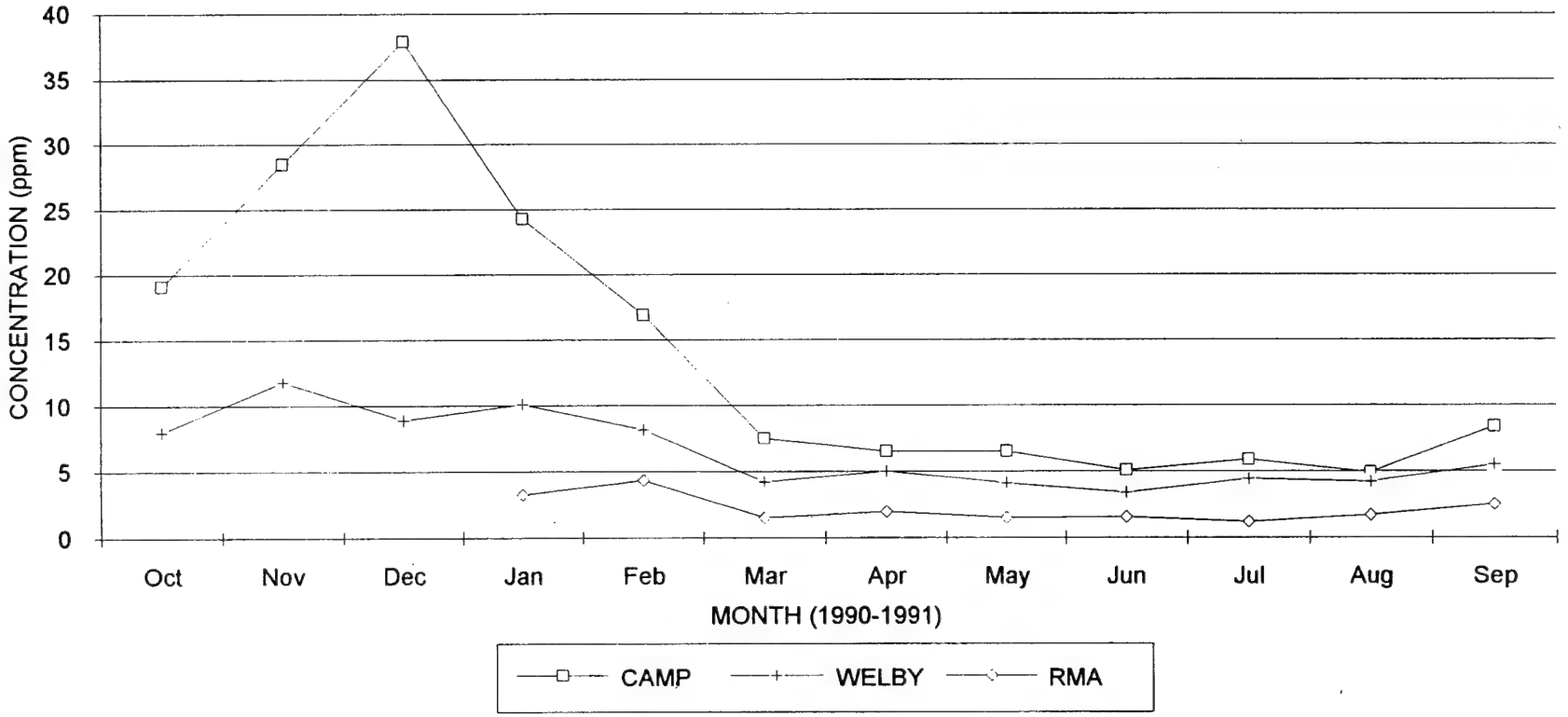
FIG. 5.3-1



Job No. :	22923E
Prepared by :	T.G.D.
Date :	7/17/92

DIURNAL CYCLE FOR CARBON MONOXIDE RMA CMP FY91

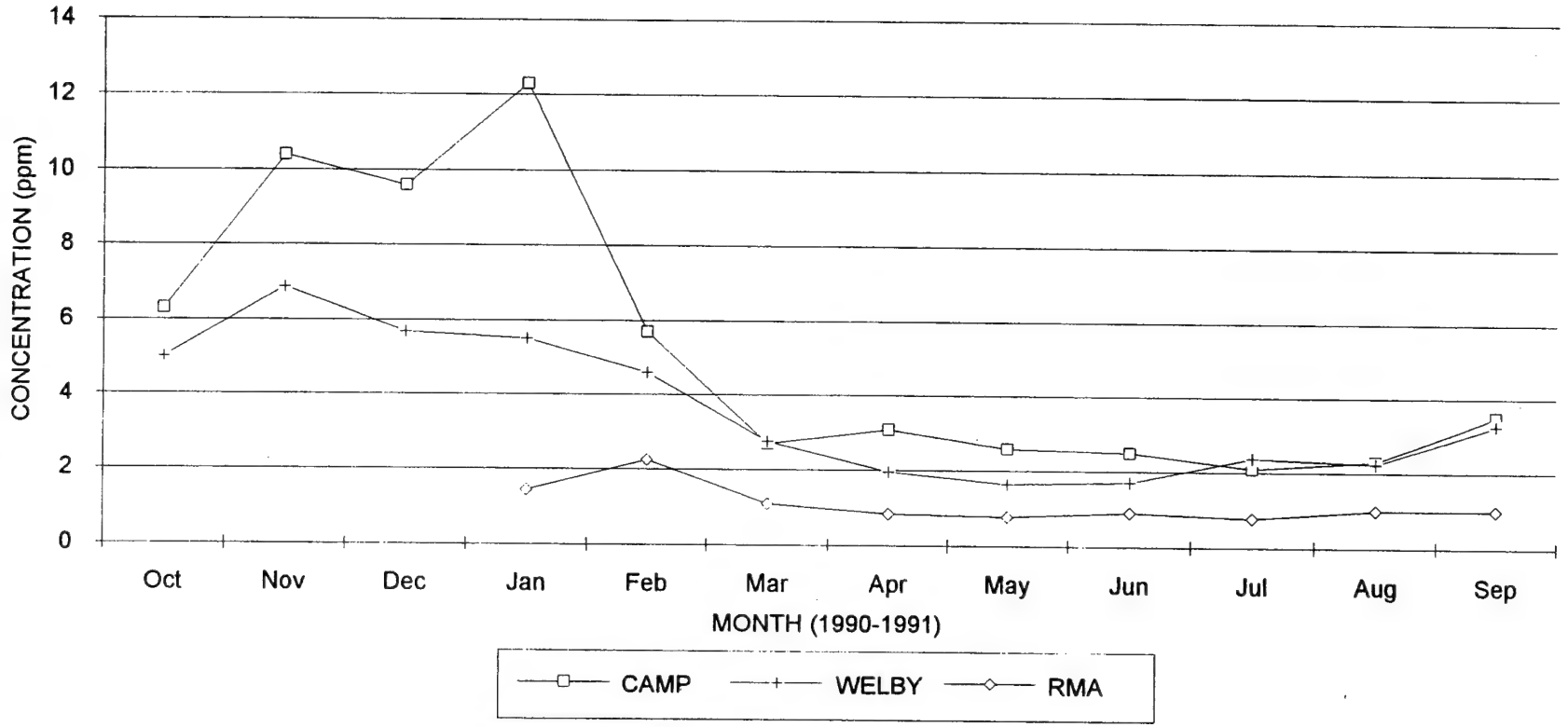
FIG. 5.3-2



Job No. :	22923E
Prepared by :	T.G.D.
Date :	7/17/92

CMP VERSUS CDH CONCENTRATION
1 HOUR MAX. CARBON MONOXIDE

FIG. 5.3-3



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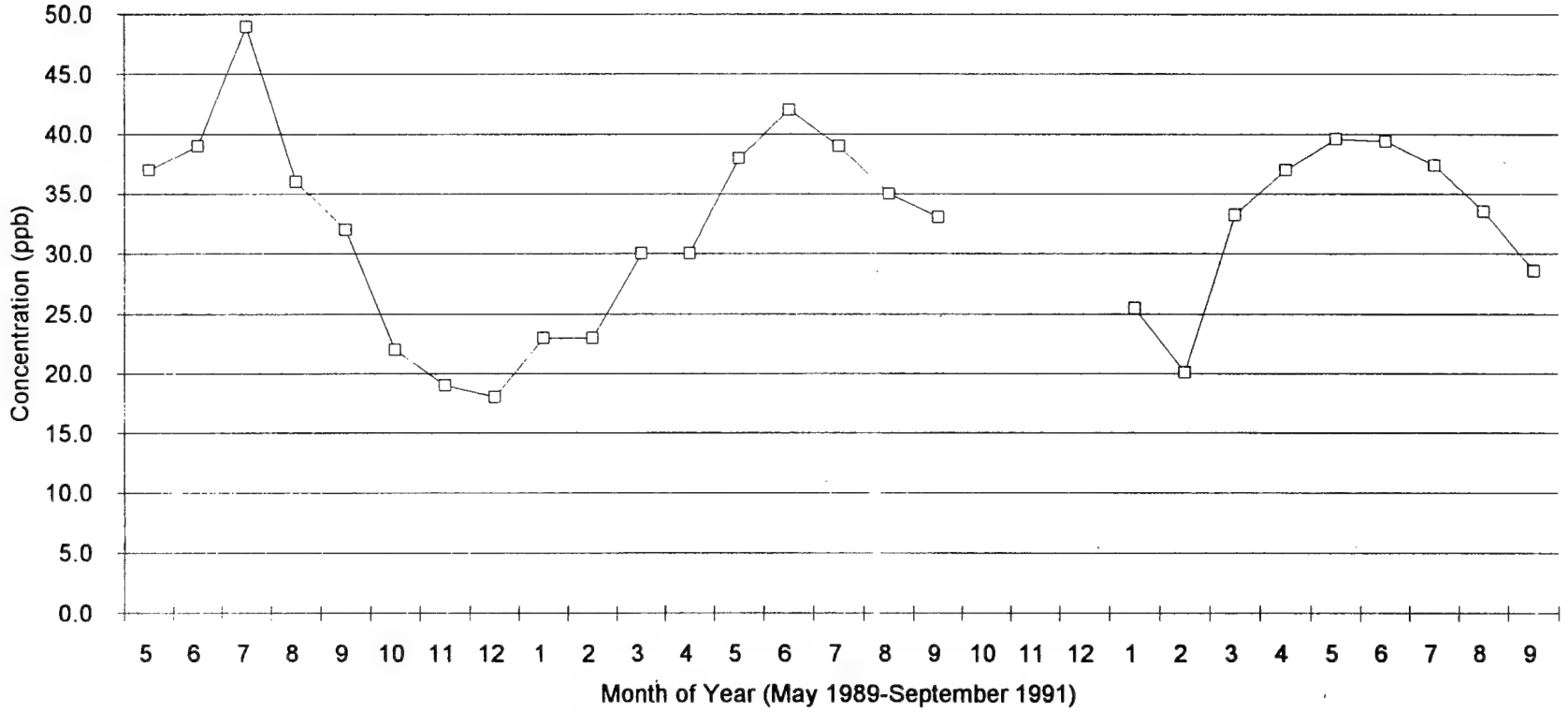
Date :	7/17/92

CMP VERSUS CDH CONCENTRATION
8 HOUR MAX. CARBON MONOXIDE

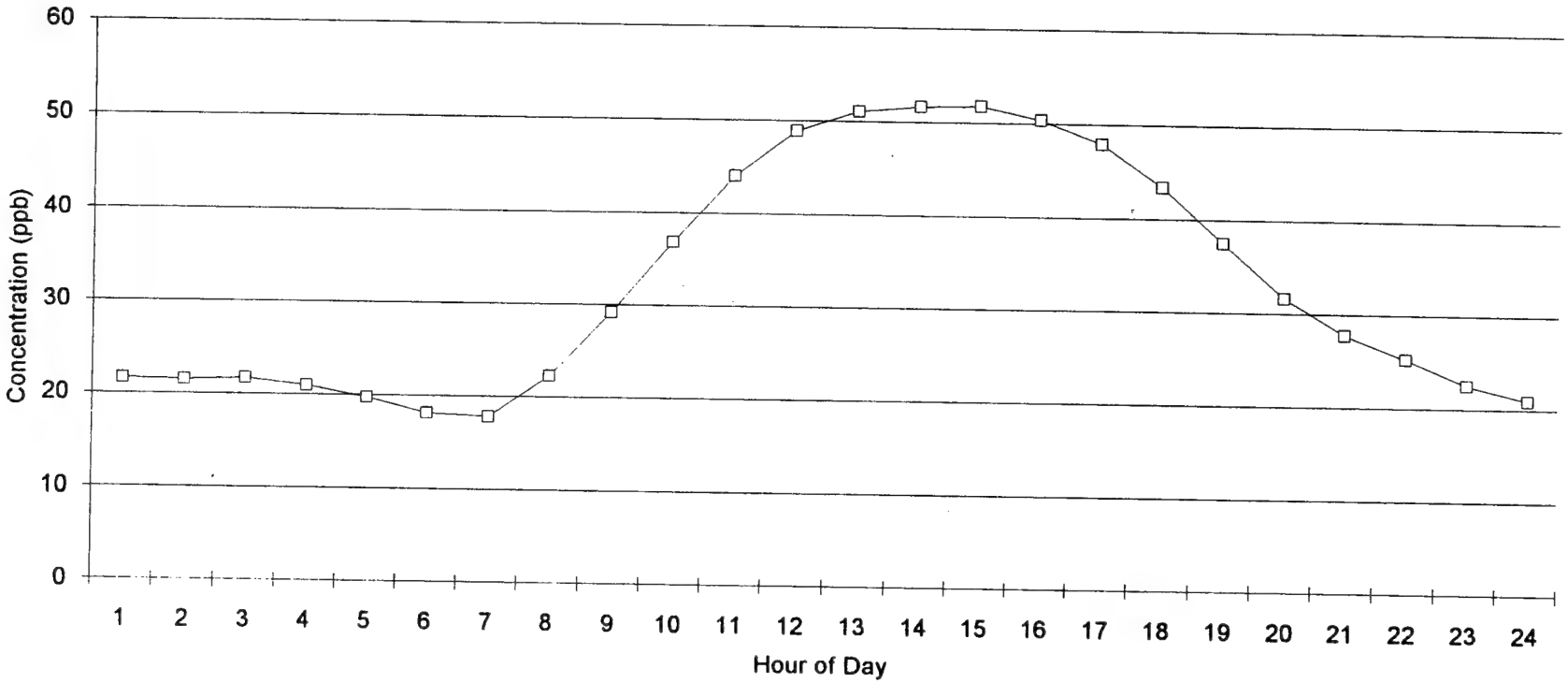
FIG. 5.3-4



Job No. :	22923E
Prepared by :	T.G.D.
Date :	7/17/92

MONTHLY MEAN FOR OZONE
RMA CMP FY91

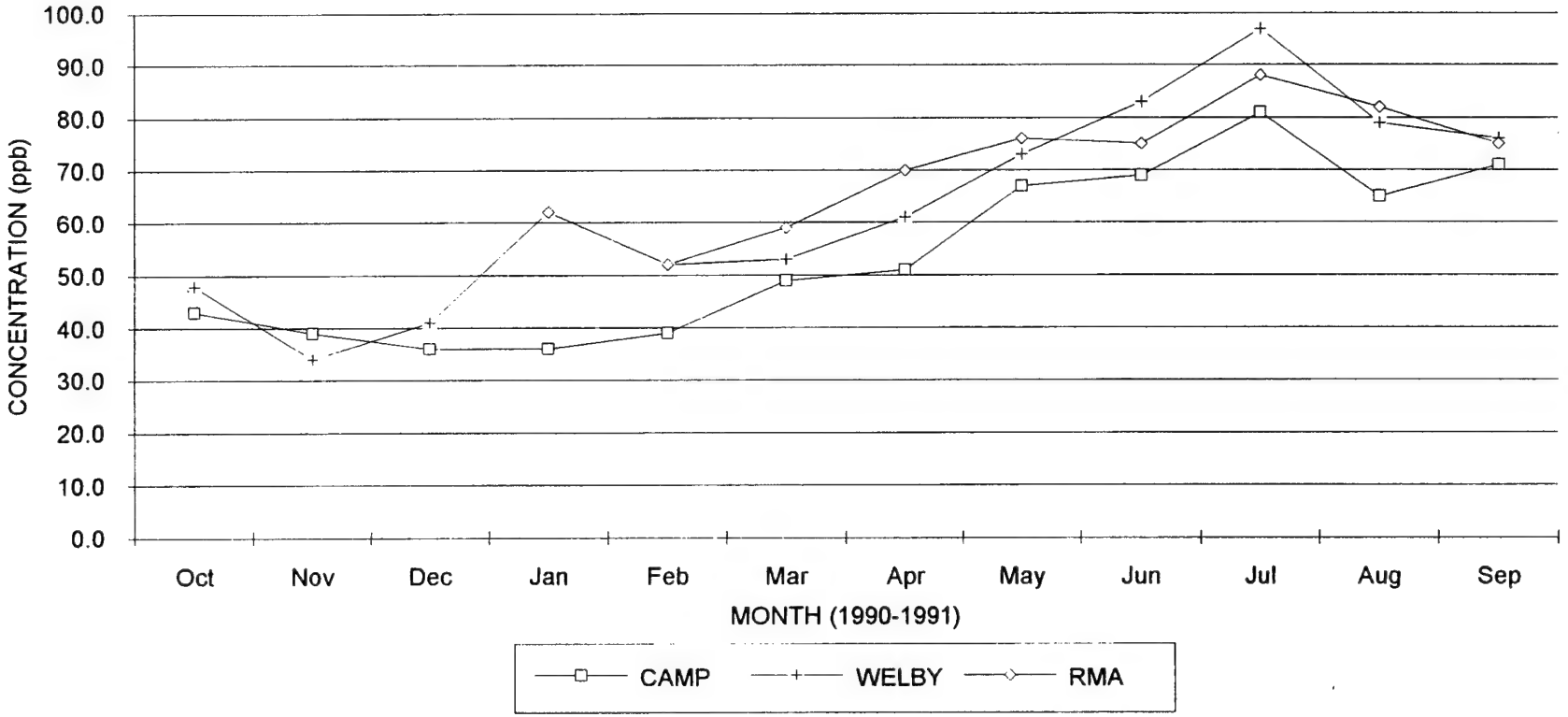
FIG. 5.4-1



Job No. :	22923E
Prepared by :	T.G.D.
Date :	7/17/92

DIURNAL CYCLE FOR OZONE
RMA CMP FY91

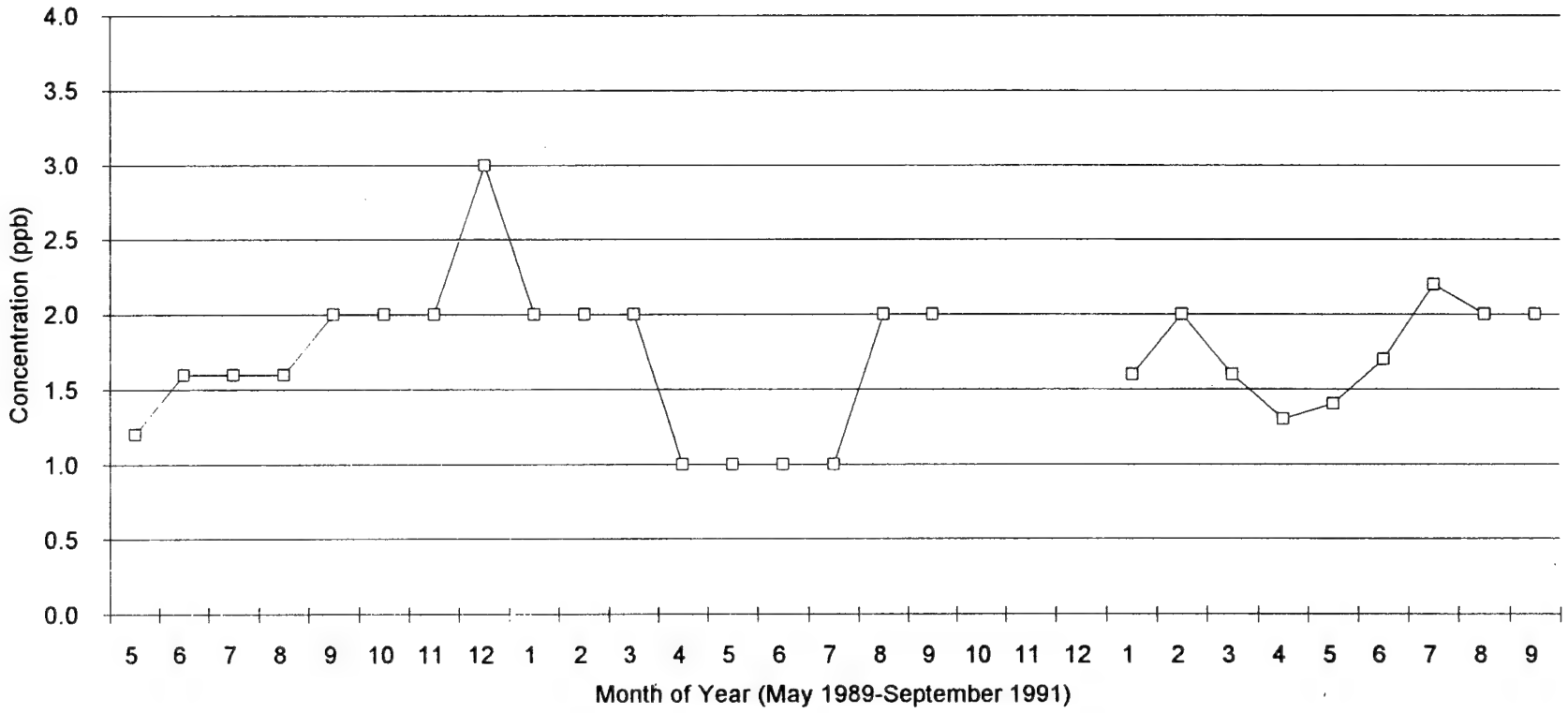
FIG. 5.4-2



Job No. :	22923E
Prepared by :	T.G.D.
Date :	7/17/92

CMP VERSUS CDH CONCENTRATION
1 HOUR MAX. OZONE

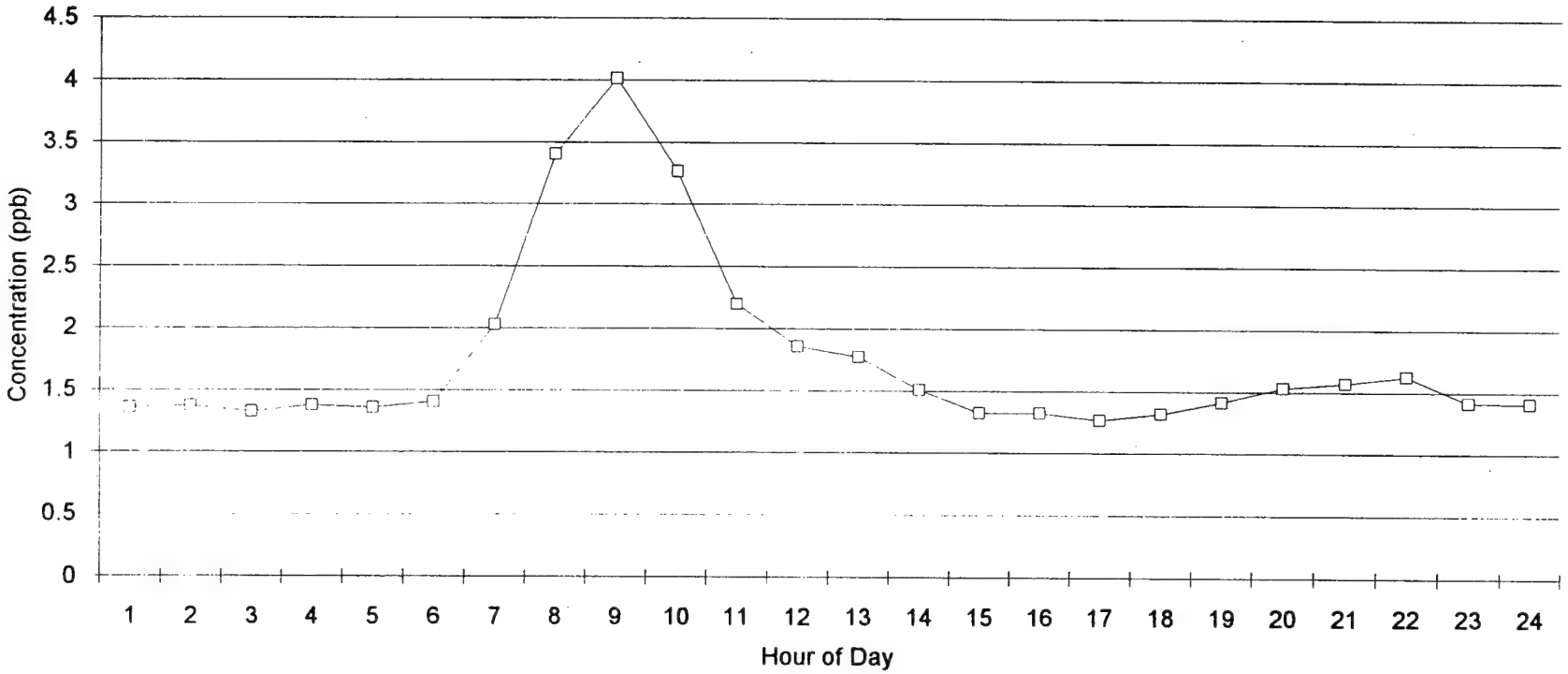
FIG. 5.4-3



Job No. :	22923E
Prepared by :	T.G.D.
Date :	7/17/92

MONTHLY MEAN FOR SULFUR DIOXIDE
RMA CMP FY91

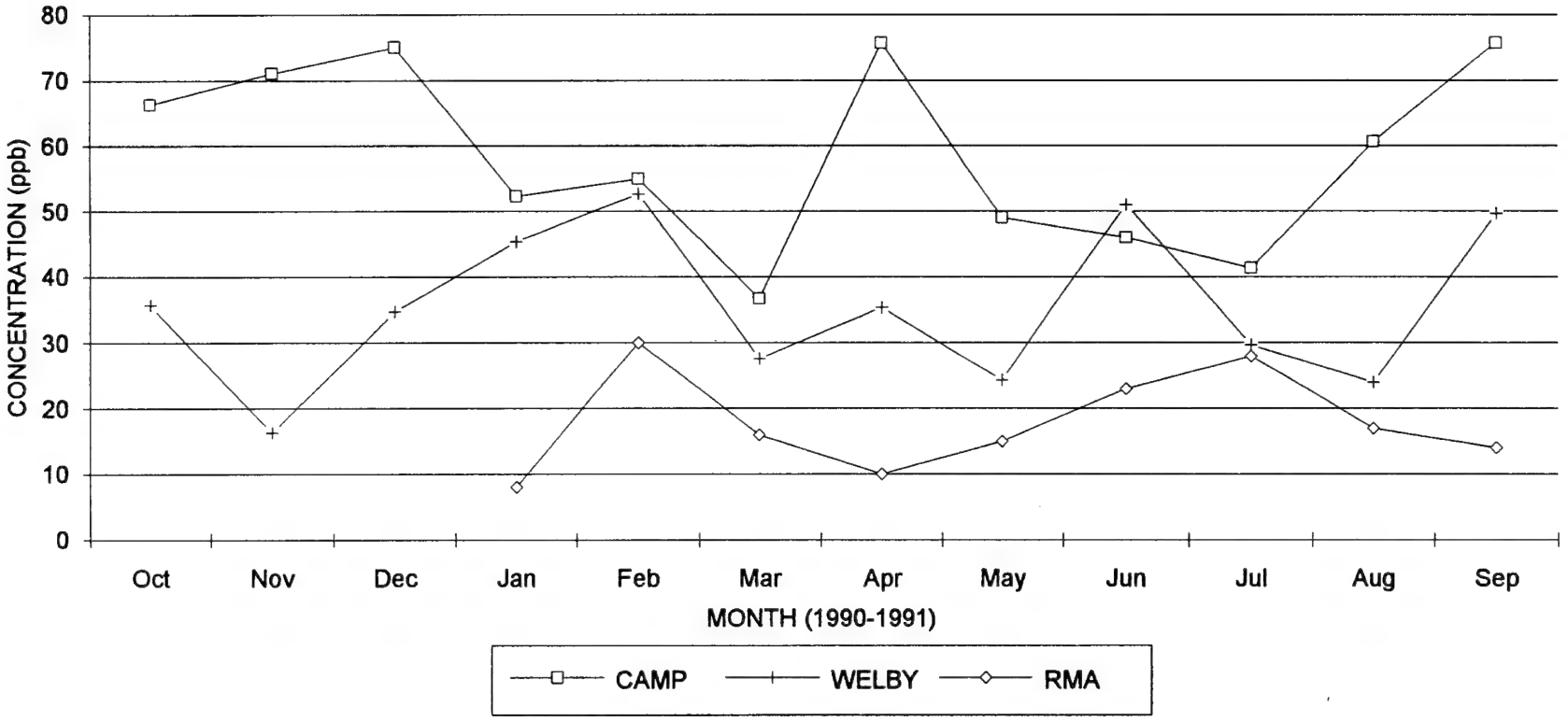
FIG. 5.5-1



Job No. :	22923E
Prepared by :	T.G.D.
Date :	7/17/92

DIURNAL CYCLE FOR SULFUR DIOXIDE
RMA CMP FY91

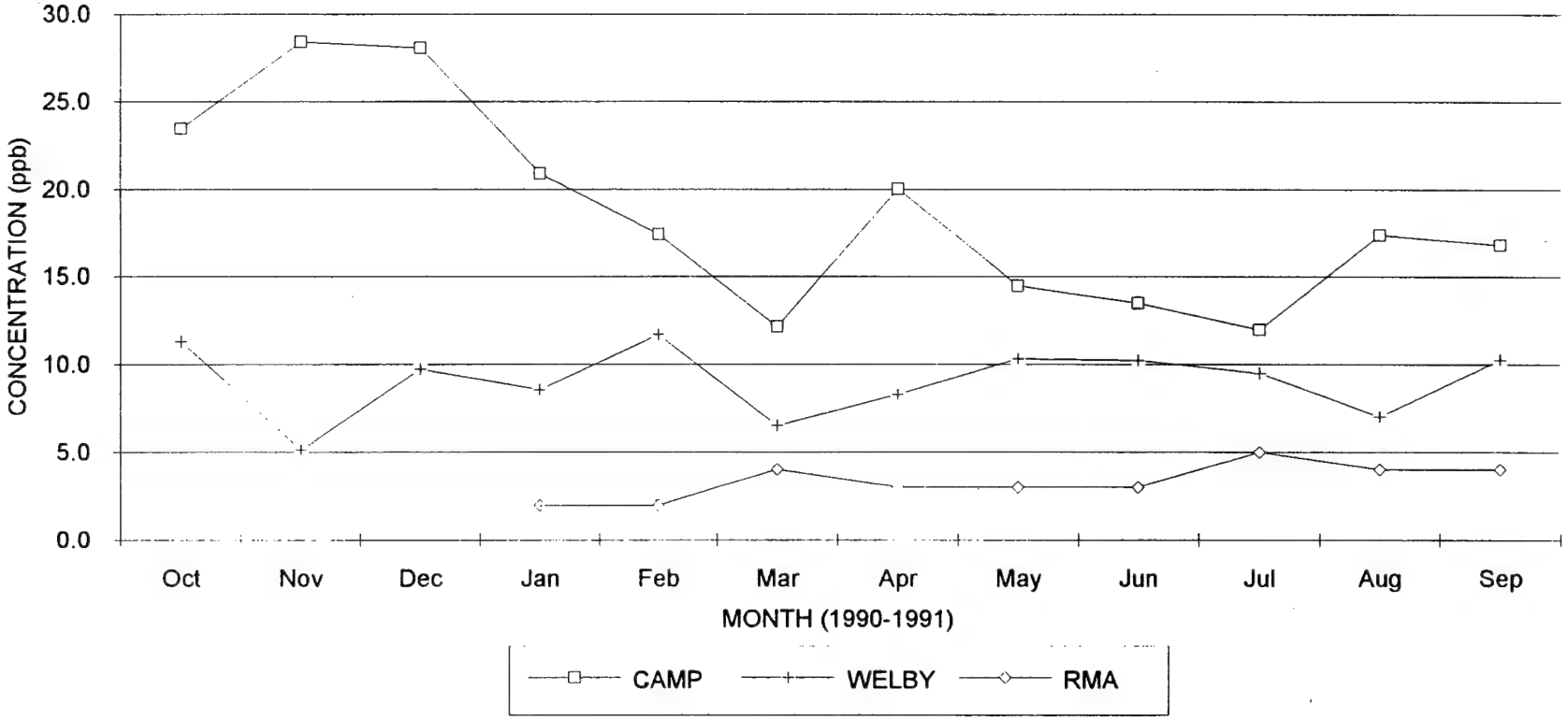
FIG. 5.5-2



Job No. :	22923E
Prepared by :	T.G.D.
Date :	7/17/92

CMP VERSUS CDH CONCENTRATION
3 HOUR MAX. SULFUR DIOXIDE

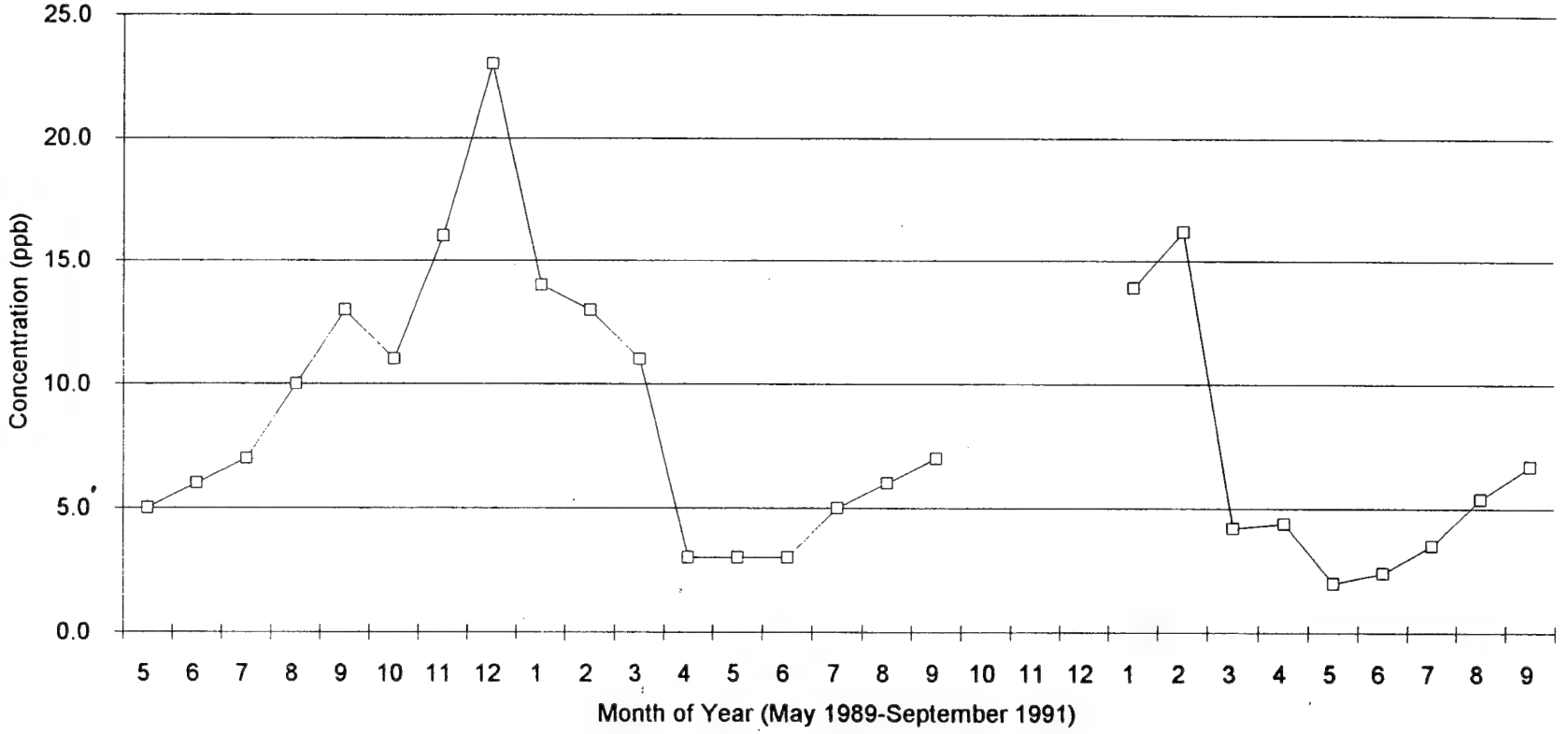
FIG. 5.5-3



Job No. :	22923E
Prepared by :	T.G.D.
Date :	7/17/92

CMP VERSUS CDH CONCENTRATION
24 HOUR MAX. SULFUR DIOXIDE

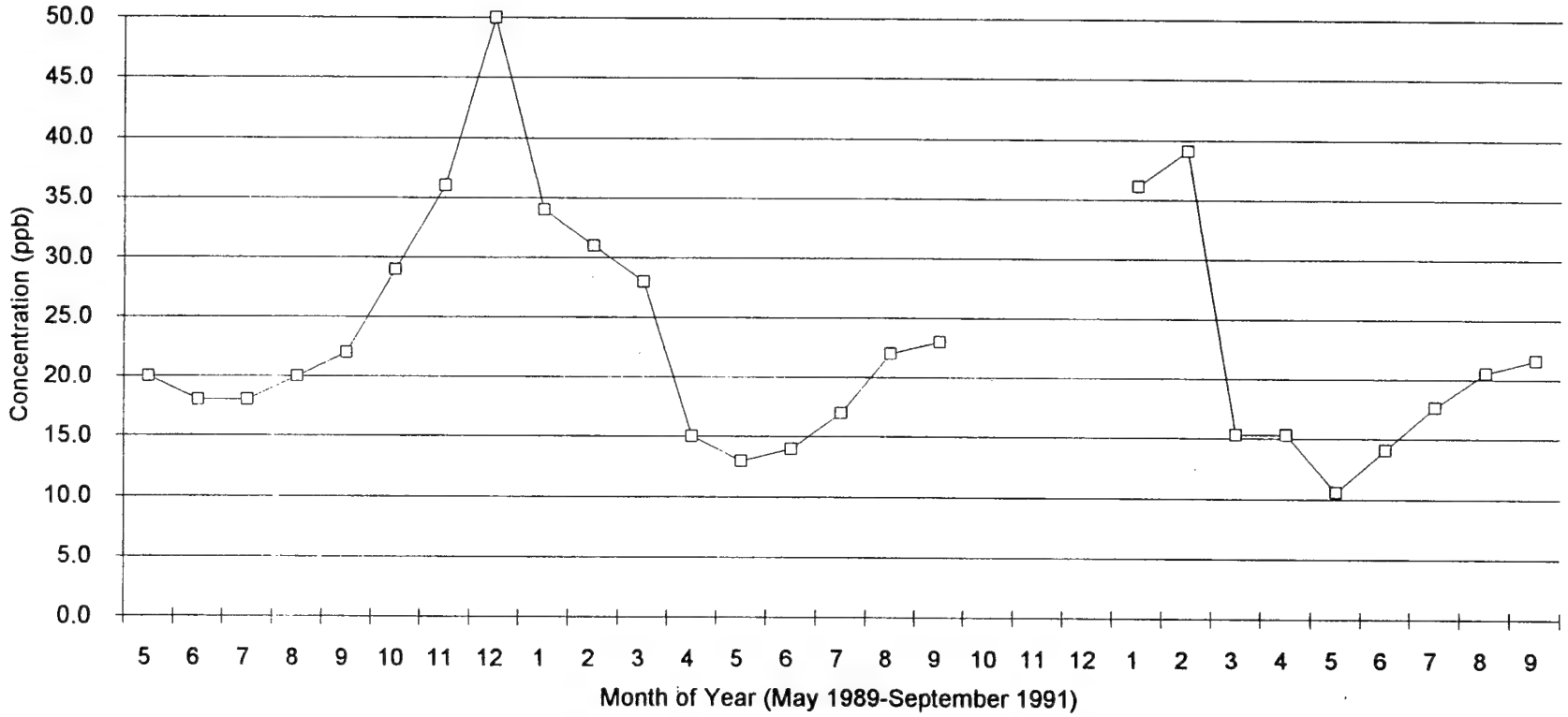
FIG. 5.5-4



Job No. :	22923E
Prepared by :	T.G.D.
Date :	7/17/92

MONTHLY MEAN FOR NITRIC OXIDE
RMA CMP FY91

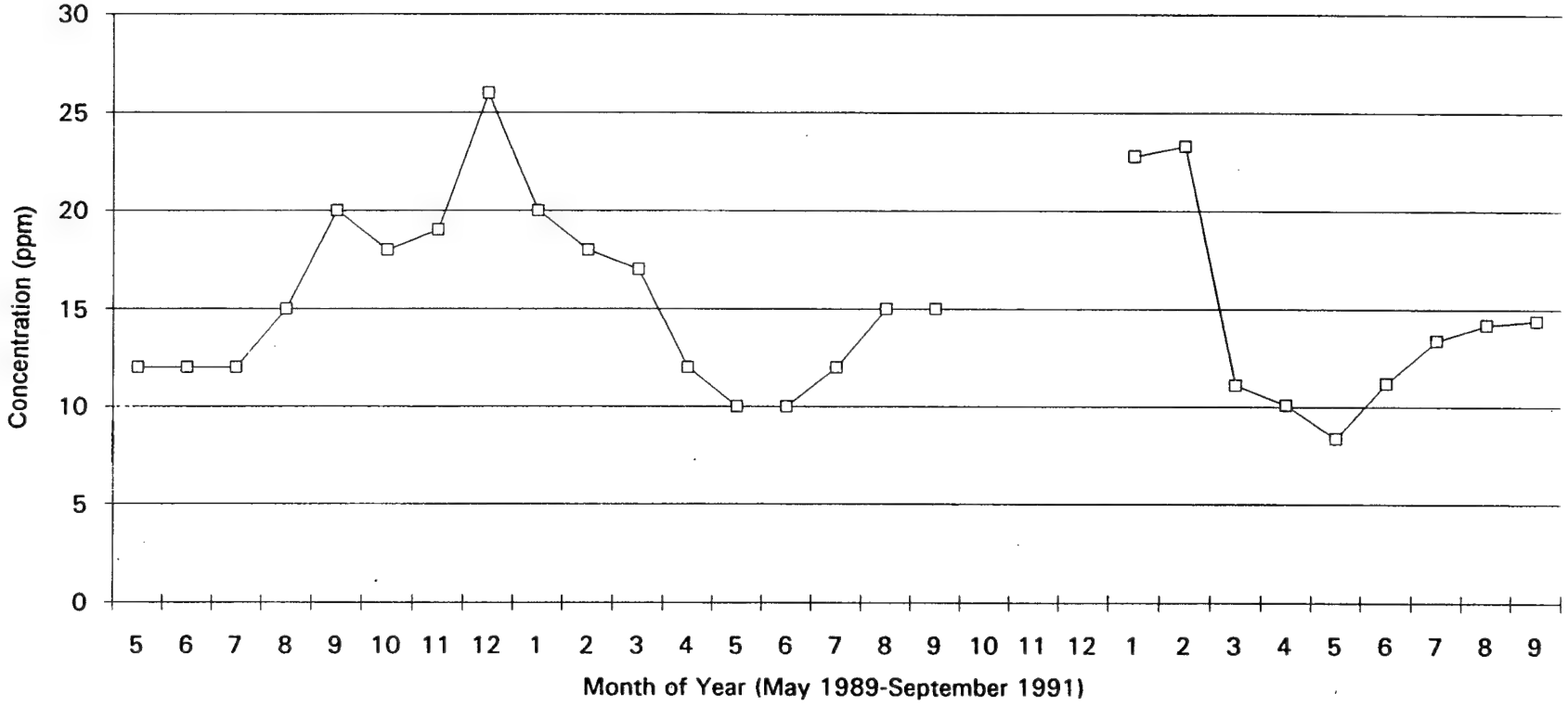
FIG. 5.6-1



Job No. :	22923E
Prepared by :	T.G.D.
Date :	7/17/92

MONTHLY MEAN FOR NITROGEN OXIDES RMA CMP FY91

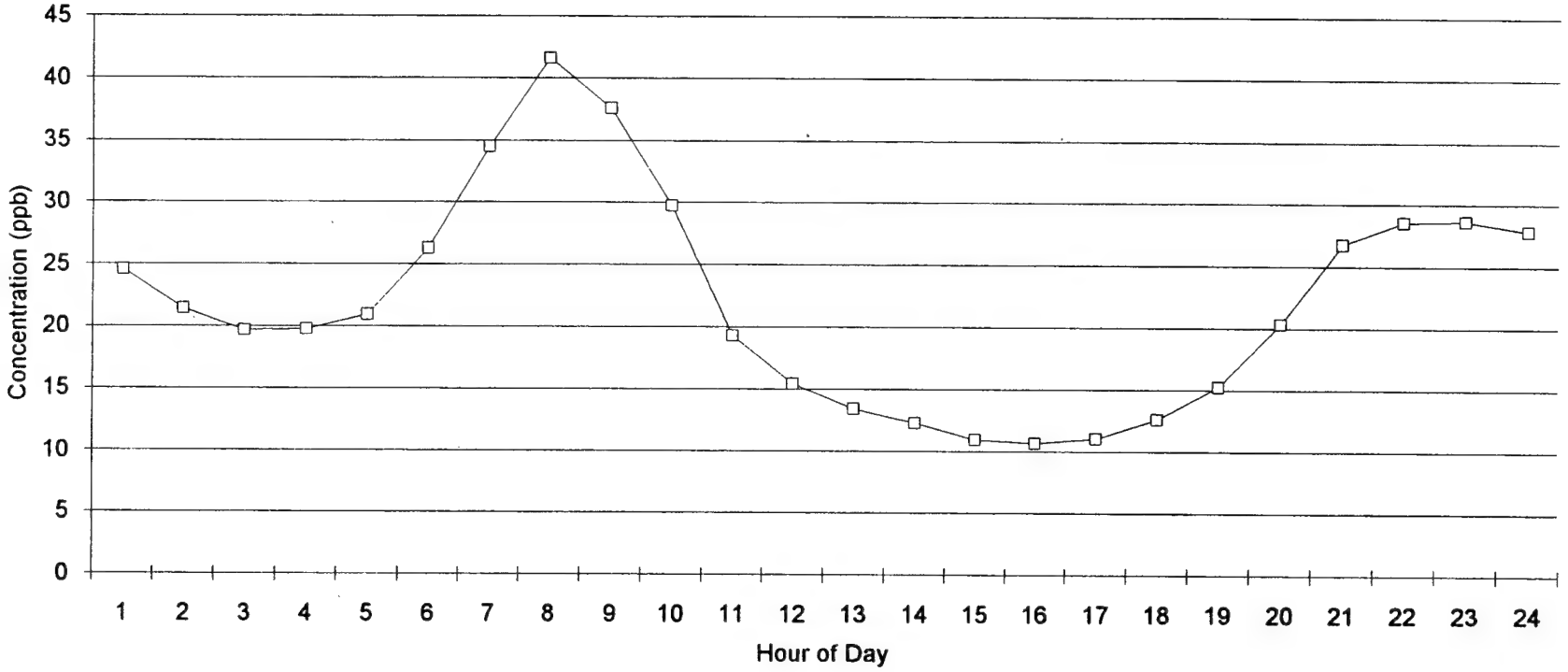
FIG. 5.6-2



Job No. :	22923E
Prepared by :	T.G.D.
Date :	7/17/92

MONTHLY MEAN FOR NITROGEN DIOXIDE RMA CMP

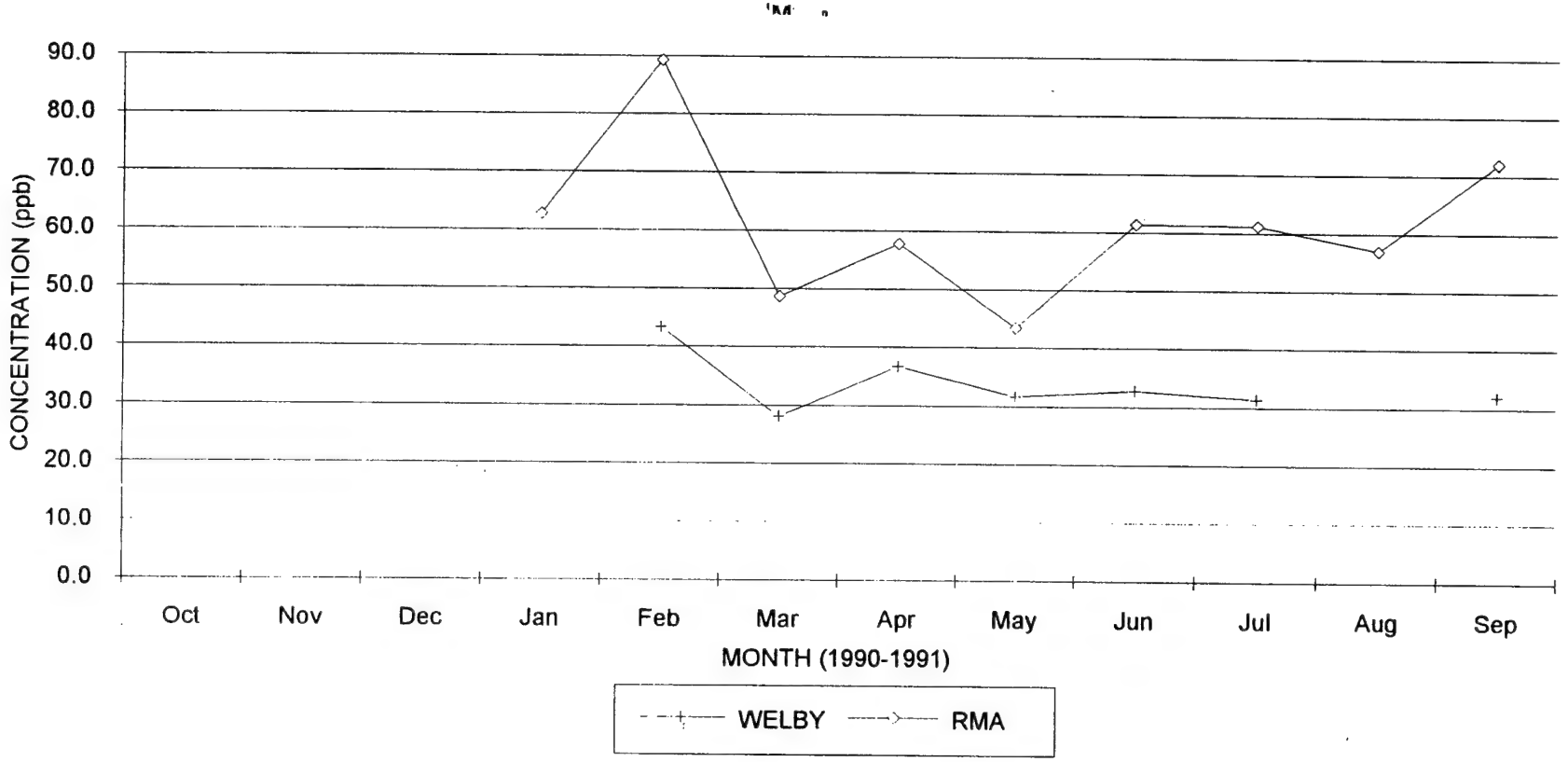
FIG. 5.6-3



Job No. :	22923E
Prepared by :	T.G.D.
Date :	7/17/92

DIURNAL CYCLE FOR NITROGEN OXIDES RMA CMP FY91

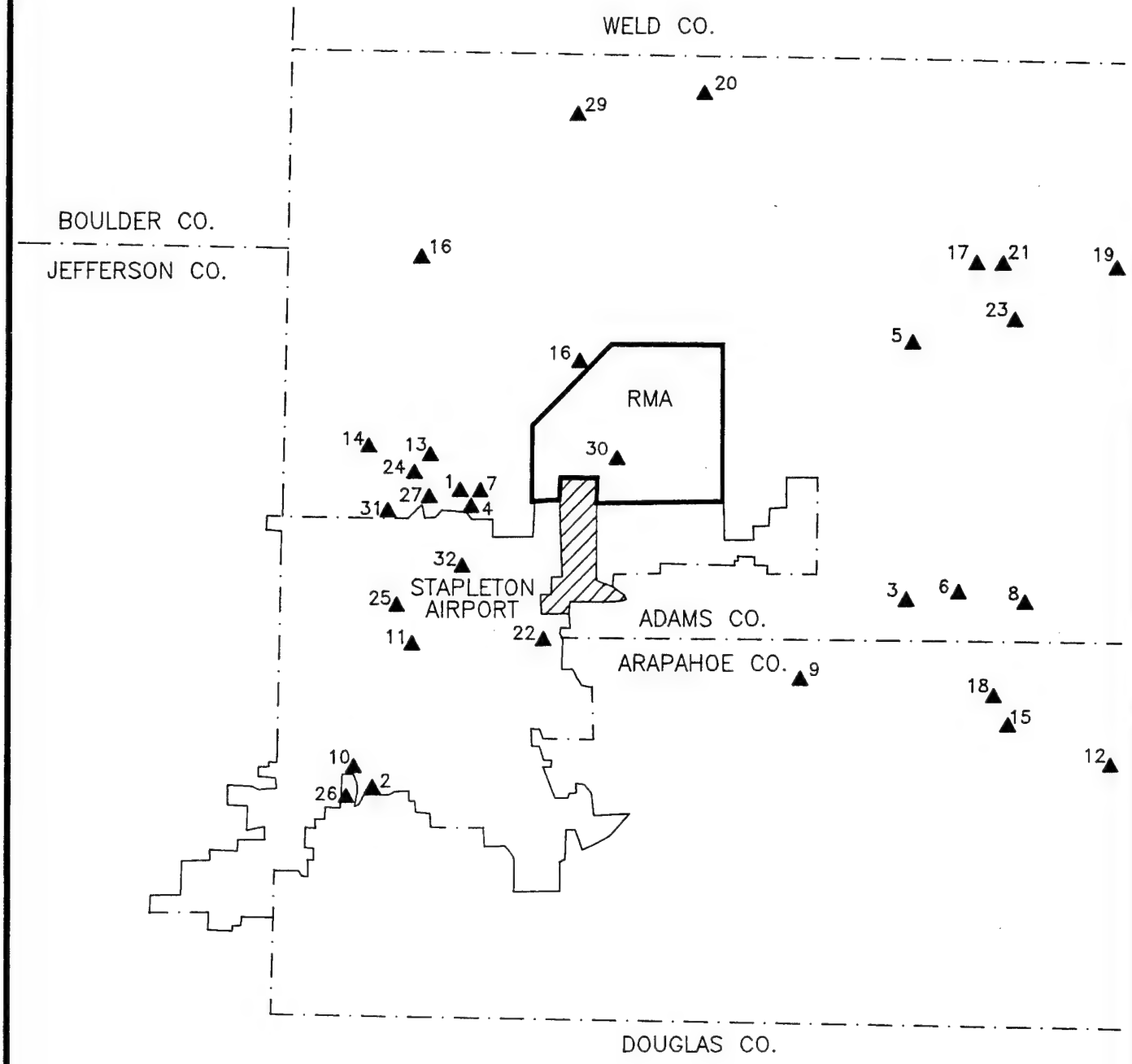
FIG. 5.6-4



Job No. :	22923E
Prepared by :	T.G.D.
Date :	7/17/92

CMP VERSUS CDH CONCENTRATION
24 HOUR MAX. NITROGEN DIOXIDE

FIG. 5.6-5



0 2.5 5

SCALE IN MILES

LEGEND

25▲ APPROXIMATE LOCATION OF SOURCE

Job No. :	22787E
Prepared by :	M.R.M.
Date :	7/1/92

SOURCE OF REGULATED POLLUTANTS IN RMA VICINITY

2787E002

FIG. 5.7–1

6.0
PHOTOGRAPHIC VISIBILITY STUDY

The Photographic Visibility Study initiated during FY90 was continued under the FY91 CMP to study the relationship between the occurrence and intensity of observed dust at RMA, brown cloud conditions over Denver metropolitan area, and air quality recorded by the CMP air monitoring program. This study incorporated the use of photographic records, photographer's observations of conditions at the time, and results of continuous air quality monitoring and particulate sampling conducted concurrently. These photographs were taken routinely (every 6th day) on EPA-scheduled air quality sampling days. On these days, samplers operated to measure total suspended particulates, PM-10, and metals concentrations. Gaseous samplers measuring CO, O_3, SO_2, NO, NO_2, and NO_x were operated on a continual basis.

Photographs were taken on high wind dust event days, in addition to the regularly scheduled sample days. These events occasionally produced high dust conditions at localized areas at RMA which had little or no vegetative cover. This portion of the visibility study was continued in conjunction with the CMP to track the effectiveness of the dust suppression treatments in the Basin A area, and also to help study the effects of high winds on the local visibility. Photographs were taken when winds were in excess of 20 mph or when dust clouds were visible in the vicinity of Basin A.

The data from this continued study further confirmed the direct relationship between visibility, wind direction, and gaseous air quality at RMA, especially when a heavy brown cloud was in evidence. Higher levels of gaseous pollutants were measured, and sampled particulate concentrations at RMA were also found to be highest at the perimeter sites when the prevailing wind was blowing from metropolitan Denver toward RMA. The following discussion describes both types of episodes which illustrate the relationship between the local weather conditions and RMA air quality.

Brown cloud days were generally associated with inversion conditions, stable air, and light to moderate winds. In contrast gaseous air quality most often improved during the period of high wind dust event days. Increased atmospheric mixing dissipated the low-

lying pollution layer and diluted the gaseous concentrations, thereby improving the local air quality. Particulate concentrations normally increased on such days, however, due to the greater size and concentration of particles which became windborne.

6.1 HIGH WIND DUST EVENTS

Disturbed areas at RMA are susceptible to a threshold of wind speeds and wind gusts which will lift dust particles off open fields. Previous studies have suggested that wind gusts in excess of 25 mph were required to significantly increase total suspended particulates (TSP) levels (RLSA 1989). Monitoring results from the CMP program also suggest an increase in TSP levels when wind speeds over 10 mph are sustained for several hours during sampling periods.

Photographs were taken during FY91 in the vicinity of Basin A whenever wind speeds were in excess of 20 mph or when dust was visibly observed in Basin A. These photographs were taken from the perimeters of Section 26, using a 35 mm lens. Table 6.1-1 provides a summary of four visibility case studies conducted at Basin A when sustained winds were in excess of 20 mph. Wind gusts ranged from 35 to 41 mph, as measured at M3, at the meteorological tower closest to Basin A. In most cases, the wind gusts during the high wind dust event were actually greater before or after the photographs were taken. Winds during the high wind dust events ranged west-northwest to south-southeast.

6.1.1 February 20, 1991

A typical high wind dust event was February 20, 1991 (Figure 6.1-1). This was a gusty day with north-northwest winds and a large amount of visible windborne dust. In the three hours following the onset of the gusty conditions, the maximum wind gusts were 35 mph and hourly average wind speeds were in excess of 20 mph. The photographs in Figure 6.1-1 show evident dust clouds in the Basin A area, with indicated dust plumes reaching a height of 15 to 20 feet. With the increased wind speed and change of wind direction from southwesterly to westerly, the concentration of monitored gaseous criteria pollutants concurrently decreased, while particulate levels clearly increased. Table 6.1-2 presents the daily summary of meteorological and gaseous monitoring data for the day.

When the winds calmed, the concentrations of gaseous pollutants increased. Figure 6.1-2 illustrates the trends of selected gases compared to wind speed and direction during this period. No particulate data were available for analysis because this was not a scheduled sample day.

6.2 BROWN CLOUD EVENTS

Photographs were taken from the M4/AQ site location on each air sampling day. These photographs recorded the visual conditions from the southwest to the northwest, between RMA and the mountains located to the west of the Denver metropolitan area. On days of inclement weather which severely limited visibility, no photographs were taken. In addition to taking photographs, the photographer recorded information such as weather conditions, ground conditions, and general visibility on the accompanying Photo Visibility Study Data Sheet. These data and the photographic evidence were then compared to gaseous air data and the particulate samples from the day. The purpose of these evaluations was to compare apparent Denver metropolitan air quality and visibility conditions to the observed air quality and visibility at RMA.

Once photographs were returned from processing, a further evaluation of visibility conditions was made. Both upper level visibility, which included prominent mountains, and lower or ground-level visibility were judged. During the summer months, the visibility at both levels was generally good, but during the winter, visibility at the lower level was often fair to poor. During the winter, the prevailing atmospheric conditions in the Denver metropolitan area include the presence of surface temperature inversions and light wind during the early morning and evening hours. These atmospheric conditions retard the mixing between the colder lower-level air and the warmer upper-level air. Such conditions allow the buildup of pollutants which become concentrated in the lower air level near the ground. The smog buildup also heavily impacts the low-level visibility across the Denver area.

Upper-level visibility was judged by the clarity of the high mountains visible from RMA. Lower level visibility was judged by the clarity of the closer landmarks such as the foothills and the buildings of downtown Denver. Visibility was judged as excellent, good, fair, or poor, depending on the degree of visibility of specific landmarks.

The criteria used to judge visibility were as follows:

Excellent Visibility - Mount Evans (a distance of 52 miles) was clear and sharp, and all closer landmarks were also unobscured.

Good Visibility - The foothills and the hogback (a distance of 21 miles) were clear and sharp, even at the very bottom. Mountains may or may not be clearly visible.

Fair Visibility - The foothills and the hogback were indistinct, but the Denver skyline (a distance of 10.5 miles) was clearly visible.

Poor Visibility - The Denver skyline was not distinct or visible.

Fifty-six percent of the cases recorded were in the poor visibility category. The CMP period evaluated in this assessment encompassed the portion of the year when the inversion conditions in the Denver metropolitan area are historically at their worst. During the summer months inversion conditions are less frequent and less intense and, consequently, air quality and visibility are much better.

6.2.1 March 19, 1991

March 19, 1991, was a high event brown cloud day during the morning hours, then a high event dust day during the afternoon. Figure 6.2-1 presents photographs of the inversion and resulting brown cloud conditions at the time. Visibility was poor, with the foothills and mountains almost completely obscured, and the buildings of downtown Denver partly hidden in the haze.

On this particular day, winds did not follow the prevailing southwesterly pattern (associated with a brown cloud movement over RMA), but the effects of the brown cloud can be tracked by following the wind directions during the latter part of March 18 and on the sample day. Winds were steady from the southeast or east-southeast for 12 hours before starting to change to the southwest and then moving to the northwest. Southeasterly winds would have steadily pushed the brown cloud to the northwest,

concentrating the pollution against the front range and improving local air quality to the southeast. When the winds changed to westerly, the brown cloud returned back across RMA, significantly raising gaseous pollutant concentrations. Winds then returned to southeasterly, with an accompanying increase in wind speeds. The higher wind speeds (averaging 36 mph at 1600 MST) caused the inversion layer to break up, resulting in greater atmospheric mixing and dramatically improved RMA air quality. Table 6.2-1 presents the daily summary of meteorological and gaseous monitoring data for the day. Figure 6.2-2 illustrates the trends in gaseous pollutants over the 24-hour sampling period.

TSP and PM-10 samples collected on the March 19 sample day illustrate higher than average particulate concentrations. Concentrations of TSPs were approximately double the normal concentrations, and PM-10 concentrations were approximately one and one-half times greater than normal concentrations. These high concentrations were most likely a combination of advection from the Denver metropolitan area during the morning inversion period, followed by windblown dust resulting from a 10-hour period with wind speeds in excess of 20 mph and gusts reaching close to 40 mph.

6.3 SUMMARY

This section has illustrated the interrelationship between visibility and air quality conditions at RMA, and meteorological factors that control the transport of potential pollutants within the metropolitan Denver area. Additional examples have been provided in Section 5.7 where emphasis was placed on specific point sources that impact the Arsenal. There is no single or dominant parameter that can be used to define or predict RMA air quality; however, multiple point sources and releases within the metropolitan area have the potential to impact the Arsenal. There are also local RMA remediation activities that are significant, depending upon the nature of the potential compounds which might be released during excavation. Overriding meteorological influences that distribute potential pollutants both into the Arsenal and out of the Arsenal exist. The CMP is attempting to identify the variable sources and influences in order that air quality data measured under the program can be evaluated in proper perspective.

TABLE 6.1-1

SUMMARY OF HIGH WIND DUST EVENTS DURING FY91

Date	Time	Wind Speed (mph)	Peak Gust* (mph)	Direction	Observation
02/20/91	1246	18-25	35	WNW	Heavy dust cloud blowing across Basin A, 15 to 20 feet above the ground. Dust heavy enough to obscure objects on the horizon.
03/08/91	1224	11-26	35	NNW	Visible dust cloud over Basin A. Dust rising 10 to 15 feet above the ground.
03/19/91	1149	16-29	41	SSE	Widespread dust cloud over Basin A. Dust plumes reaching a height of 10 to 15 feet above the ground.
05/09/91	1455	17-24	38	S	Light dust cloud 1 to 4 feet above the ground surface at Basin A. (Wind speeds increased after the photograph was taken.)

* Peak wind gust measured during the high wind dust event.

TABLE 6.1-2

FEBRUARY 20, 1991, DUST EVENT DATA

Date	Hour	O_3 ppb	CO ppm	SO_2 ppb	NO ppb	NO_2 ppb	NO_x ppb	Wind Speed mph	Wind Dir. deg.	Max** Gust
2/20	100	8.86	.470	998*	12.21	31.62	44.67	11.44	235.9	12.40
2/20	200	16.6	.457	998	8.67	21.62	31.15	9.51	246.3	11.26
2/20	300	18.63	.497	998	7.94	19.74	28.59	6.643	209.9	10.35
2/20	400	20.07	.492	998	6.927	18.96	26.81	5.174	207.6	8.07
2/20	500	16.57	.515	998	6.075	19.62	26.65	6.805	169.3	8.38
2/20	600	14.16	.540	998	5.787	24.65	31.35	8.04	203.2	10.89
2/20	700	9.11	.702	998	7.15	32.11	40.12	10.60	210.8	11.20
2/20	800	9.56	1.023	998	19.97	35.71	56.51	8.48	228.3	13.53
2/20	900	15.1	1.197	998	29.72	32.7	63.25	11.93	211.5	12.51
2/20	1000	22.54	1.094	998	31.81	31.09	63.73	13.66	233.3	20.56
2/20	1100	42.21	.405	998	10.0	2.881	13.86	19.23	284.6	23.80
2/20	1200	44.07	.406	998	4.814	1.0	7.32	21.26	287.5	27.57
2/20	1300	43.48	.412	998	4.304	1.0	7.20	24.13	274.4	35.42
2/20	1400	43.21	.424	998	3.883	2.02	6.878	25.87	273.7	35.04
2/20	1500	43.62	.420	998	5.368	2.002	8.39	25.81	266.6	34.99
2/20	1600	42.29	.444	998	7.26	4.002	12.26	14.20	271.7	20.97
2/20	1700	40.81	.447	998	6.635	4.772	12.39	21.82	275.5	31.46
2/20	1800	37.35	.499	998	4.099	6.783	11.85	16.28	278.7	25.35
2/20	1900	21.21	.631	998	5.52	24.44	30.86	10.82	262.6	17.08
2/20	2000	9.7	.754	998	5.58	38.83	45.21	7.51	249.3	14.17
2/20	2100	17.78	.782	998	5.148	27.91	33.92	5.845	268.4	14.17
2/20	2200	30.49	.542	998	4.475	12.49	17.90	9.81	270.1	13.63
2/20	2300	3.59	1.04	998	24.56	45.90	71.20	10.78	227.9	11.73
2/20	2400	1.0	1.263	998	34.68	47.74	83.10	8.38	194.4	10.08

*998 denotes equipment out of service for calibration.
**Max gust wind speed taken from meteorological tower M3.

TABLE 6.2-1

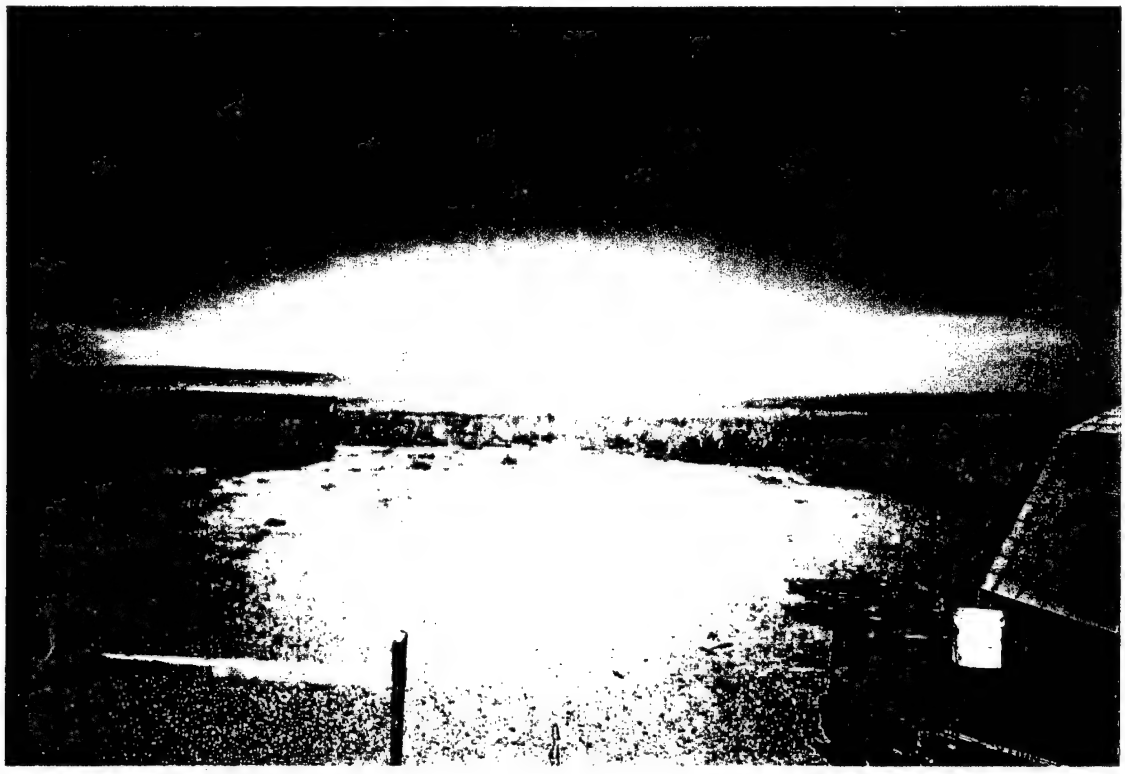
MARCH 19, 1991, BROWN CLOUD EVENT DATA

Date	Hour	O_3 ppb	CO ppm	SO_2 ppb	NO ppb	NO_2 ppb	NO_x ppb	Wind Speed mph	Wind Dir. deg.	Max* Gust	Temp
3/19	100	32.52	.317	1	1	11.03	12.12	9.57	171.2	15.84	39.81
3/19	200	40.43	.258	1	1	6.269	7.06	6.593	177.6	21.9	39.66
3/19	300	44.76	.228	1	1	4.083	5.034	9.61	182.5	22.8	39.27
3/19	400	37.21	.303	1	1	11.94	12.97	9.23	207.3	15.0	39.25
3/19	500	40.51	.243	1	1	6.093	7.77	12.67	201.8	18.97	37.89
3/19	600	14.84	.502	1	2.826	26.59	30.27	7.09	249.8	13.96	33.30
3/19	700	6.723	.599	1	10.69	31.55	43.07	3.288	278.0	6.11	31.89
3/19	800	19.33	.549	1	9.84	18.75	29.45	2.779	286.3	4.97	34.04
3/19	900	21.76	.875	3.663	21.24	28.57	50.64	2.966	302.6	6.07	38.11
3/19	1000	26.17	.976	13.2	23.17	35.99	59.88	2.889	346.6	19.99	43.43
3/19	1100	47.07	.283	1	2.816	7.05	10.88	19.33	187.4	25.98	50.24
3/19	1200	49.94	.249	1	2.787	4.645	8.43	24.49	174.1	30.69	52.76
3/19	1300	51.25	.233	1	2.017	3.459	6.468	29.87	172.3	35.23	55.68
3/19	1400	51.20	.225	1	1	2.809	5.453	32.97	165.4	37.99	57.8
3/19	1500	51.0	.211	1	1	2.454	5.16	34.18	163.6	40.61	58.7
3/19	1600	49.55	.207	1	1	2.407	4.977	35.77	15.7	39.58	56.69
3/19	1700	47.91	.254	1	1	3.952	5.594	30.66	166.8	38.72	54.02
3/19	1800	47.66	.278	1	1	5.197	6.642	29.34	168.4	33.58	53.02
3/19	1900	46.23	.275	1	1	4.876	5.83	29.92	167.4	36.39	49.69
3/19	2000	42.37	.319	1	1	7.57	8.12	26.15	173.4	32.37	48.38
3/19	2100	39.38	.322	1	1	10.07	10.04	21.89	187.4	24.43	47.30
3/19	2200	23.41	.414	6.47	1	25.67	25.79	12.56	231.4	22.29	47.96
3/19	2300	24.23	.461	2.154	1	23.3	24.77	7.89	219.9	19.78	48.04
3/19	2400	48.7	.206	1	1	4.317	6.793	14.95	261.2	28.86	46.63

* Max gust wind speed taken from meteorological tower M3.

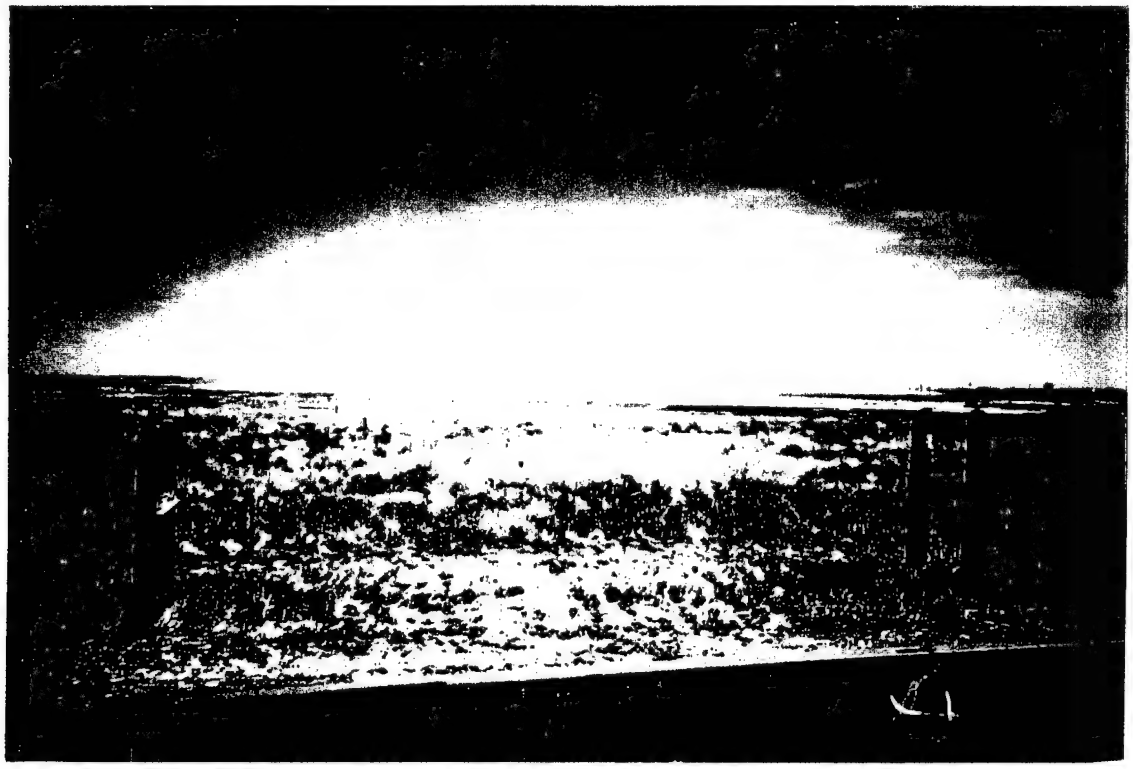
Figure 6.1-1 Dust Event: February 20, 1991

Photo 1: Time of Day: 1246 MST Direction of Photo: North

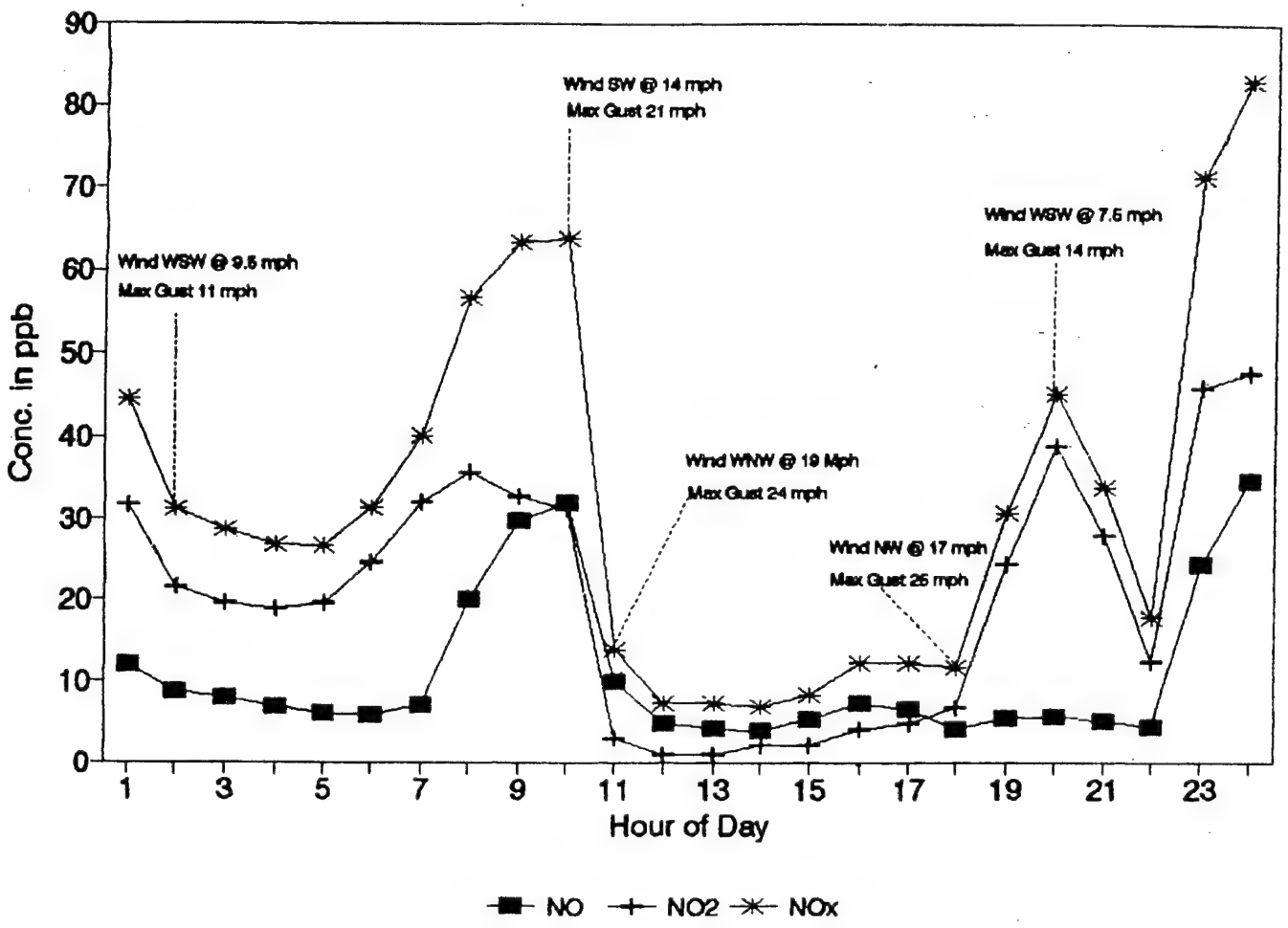


Note: Visible dust cloud below the horizon in left center of photo, centered on Basin A.

Photo 2: Time of Day: 1247 MST Direction of Photo: East across Basin A.



Note: Visible dust cloud in center of photo.



Job No. : 22787E	FEBRUARY 20, 1991 DUST EVENT DAILY METEROLOGICAL AND NO GASEOUS DATA
Prepared by : M.R.M.	
Date : 8/3/92	

FIG. 6.1-2

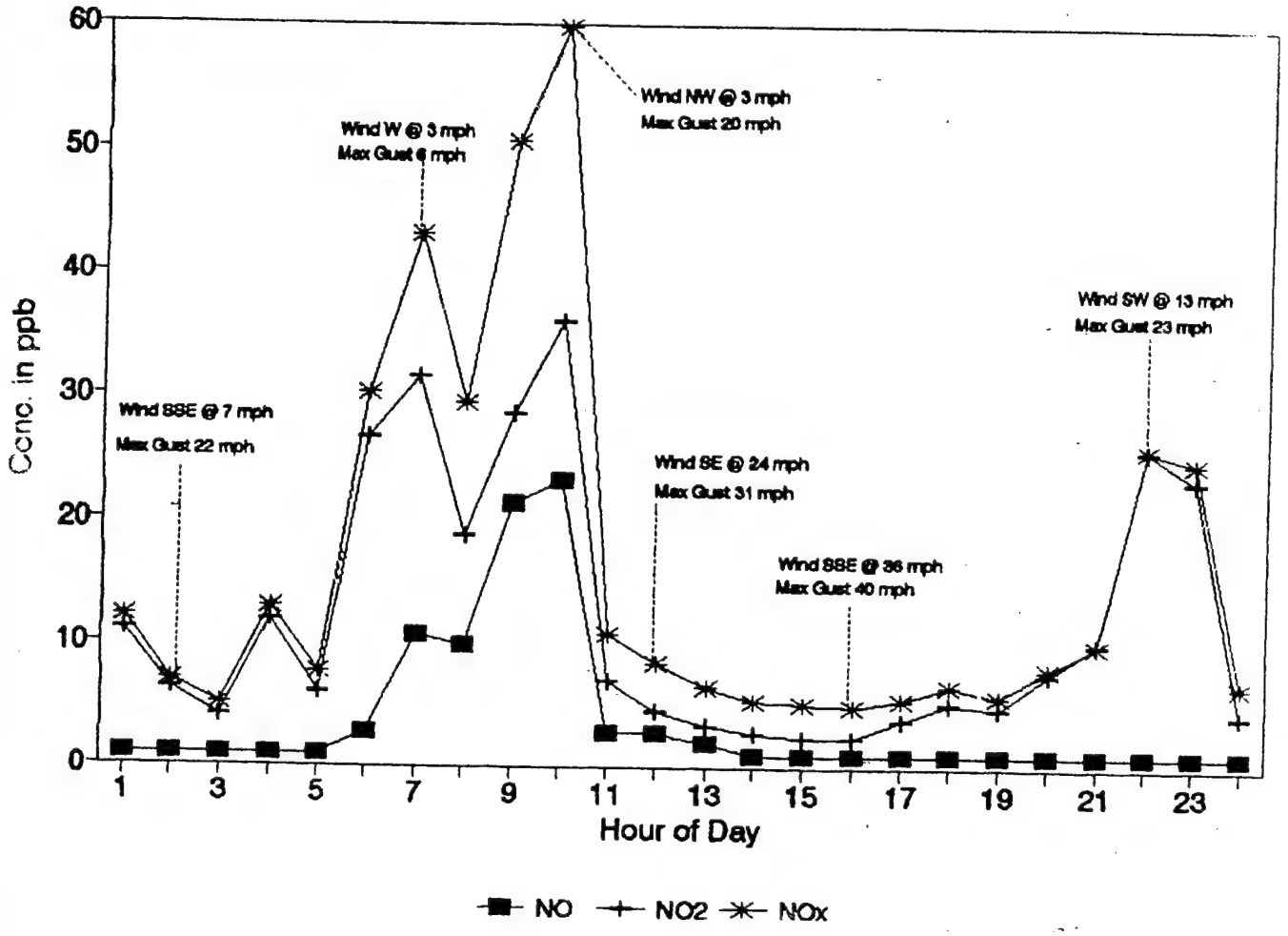
Figure 6.2-1 Brown Cloud Event: March 19, 1991

Photo 1: Time of Day: 1123 MST Direction of Photo: Southwest

Note: Heavy haze obscures the mountains and foothills. Downtown Denver is indistinct.

Photo 2: Time of Day: 1123 MST Direction of Photo: North

Note: Brown tinge is visible in the northwestern sky. Mountains and foothills are nearly invisible.



Job No. :	22787E
Prepared by :	M.R.M.
Date :	8/3/92

MARCH 19, 1991 DUST EVENT DAILY METEROLOGICAL AND NO GASEOUS DATA

FIG. 6.2-2

7.0
METEOROLOGICAL MONITORING AND DISPERSION MODELING PROGRAMS

7.1 METEOROLOGICAL PROGRAM OVERVIEW

The meteorological program and station locations are described in Section 3.5. A modification to the program placed meteorological monitoring, maintenance and data processing, and analysis under CMP responsibilities in FY89. Complete listings of all data collected and used in this report are provided in Appendix I. Pertinent summaries of wind speed, wind direction, temperature, relative humidity, barometric pressure, solar radiation, precipitation, and stability are provided in the following sections.

7.1.1 Program Objectives

The meteorological assessment has several objectives. The first is to identify atmospheric conditions associated with typical and potentially high contamination levels resulting from existing sources and remedial activity at RMA. Prevailing wind flow, wind speed, peak wind gusts, temperature, and precipitation all influence the release and spread of atmospheric emissions. A meteorological database has, therefore, been established to identify typical relationships and to examine seasonal and diurnal patterns. For example, gusty winds will often result in higher levels of total suspended particulates, inhalable particulates of less than 10 microns, metals, and possibly semivolatile organic compounds. This information is pertinent to interpreting air sampling results. Certain pollutant emissions may be more prevalent in summer than in winter, which may be an important factor for remediation planning. Also, diurnal influences (such as the formation of a drainage wind pattern during evening and early morning inversion periods) may result in significantly higher levels of certain pollutants. This information is useful in assessing the potential spread of contaminants and possible mitigating measures during remedial activities.

Another objective of the meteorological assessment is to determine the representativeness of the meteorological data with respect to associated air quality

conditions. Meteorological factors change not only from season to season, but also from year to year. Variations in these elements, as previously noted, will influence air sampling results. A particular sampling program, a period with anomalous precipitation or drought conditions, extensive snow cover, strong winds, very warm temperatures, or even generally poor dispersion conditions will have a direct influence on pollutant levels at specific monitoring site locations. This information is essential for interpreting the results. Consequently, this meteorological data will be useful in assessing remediation progress over the total period of the CMP.

In addition to the above factors, the meteorological program directly supports air quality model applications that are used in pollution dispersion evaluations and predictions. These analyses are employed for assessing impacts beyond the RMA boundary, and in predicting real-time pollution levels during remedial activities.

7.1.2 Data Recovery

Details of the recovery of FY91 meteorological data for each parameter of the composite database are given in Table 7.1-1. Recoveries are based on the total number of hours of possible data during the period October 1, 1990, through September 30, 1991 (8,760 hours). All observations (hourly values) were considered invalid or missing if there were less than 45 minutes of valid recorded data for that parameter or if there were equipment calibrations or malfunctions.

No data were collected at Meteorological Station 1 (M1), Meteorological Station 2 (M2), and Meteorological Station 3 (M3) from October 1 through December 31, 1990, due to a lapse in the CMP service contract. Data were collected at Meteorological Station 4 (M4), and these data are considered reliable because biweekly precision checks were not required.

7.1.3 Databases

A single, representative composite database was developed from data collected at all four RMA sites. Site M4 was the primary source for the composite database for all of FY91. Data from other sites, when available were also used to fill in or substitute for

the invalid or missing data. The amount of substituted data is fairly small, (generally less than 3 percent). Certain parameters are taken from different sites for the composite database since no one site monitors all the parameters. Relative humidity, maximum gust, and temperature difference were taken from M1, and solar radiation was taken from M2. All other meteorological parameters were taken from M4. Complete listings of the composite day analysis and the associated joint frequency distributions used for this report are provided in Appendix I. The RMA composite database which appears in Appendix I provides a suitably representative sample of meteorological conditions at RMA for FY91.

Separate databases were also maintained for each site (M1, M2, M3, and M4), without any substitutions being made for missing or invalid data. These databases were used for site comparisons within the RMA boundary to note any areal differences. The joint frequency distributions for each site are provided in Appendix I.

All summaries shown in this report were prepared under the CMP and taken from the FY91 composite database. Comparison of the four meteorological sites (Section 7.5) involves each of the separate databases. All data, including the substituted data, have been thoroughly checked for quality. Long-term climatological Denver Stapleton Airport means (Section 2.2) were used for comparison. The FY88, FY89, and FY90 data were also used for comparison. Pertinent summaries of the parameters listed above are presented in the following sections.

7.2 SUMMARY OF RESULTS

A summary of monthly and annual (October 1, 1990, through September 30, 1991) meteorological data for FY91 at RMA is provided in Table 7.2-1. All parameters summarized in this table are based on hourly averaged values with the exception of maximum gust, which is the maximum instantaneous wind speed for the period. Maximum speed is the maximum 1-hour average wind speed value for the period. The predominant wind direction indicates the sector (of 16 possible sectors) from which the wind is blowing most frequently during the reported period. Temperature difference is the difference in temperature between the 10-meter and 2-meter sensors (10m minus 2m).

The monthly means and extremes of temperature values clearly depict the typical annual cycle, with only minor deviations from the normal. The precipitation data revealed an annual cycle, but it was somewhat masked by individual events. The period was much wetter than the previous two years. Wind speed data showed the strongest winds during the spring months, but the maximum gusts were clearly dominated by single events. The predominant wind direction during FY91 was from the south, which is the expected prevailing pattern of southerly winds. Stability patterns showed a maximum of stable conditions in the fall and winter and a maximum of unstable conditions in the spring and summer. A neutral stability condition prevailed during all months with almost half the total frequency of occurrence.

The parameters are discussed in more detail below. Included are discussions of FY91 conditions in comparison to FY89 and FY90 data (where applicable) and to the long-term climatology at Stapleton Airport. Also, specific conditions, extreme events, and anomalous conditions are described for each parameter.

7.2.1 Temperature

The RMA FY91 annual mean temperature, 49.5°F, was very close to normal. The year itself was near or slightly warmer than normal, with only minor deviations. The summer months of July and August were somewhat cooler (2.4°F and 0.7°F below normal, respectively) due to increased rainfall. January was somewhat cooler, at 4.3°F below normal. The maximum monthly average was 71.5°F in July, and the minimum monthly average was 24.5°F in December. The maximum temperature, 96.0°F, was recorded in June during a short heat wave, and the minimum temperature, -23.2°F, was recorded in December during a cold wave.

7.2.2 Relative Humidity

The annual mean relative humidity for FY91, 49.2 percent, was near normal. All months followed quite closely to the normal mean relative humidity for each month, with higher values in the winter and spring due to lower temperatures and increased amounts of precipitation, and lower values in the summer and fall due to higher temperatures. The

maximum monthly average was 56 percent relative humidity in September and January, and the minimum monthly average was 41 percent relative humidity in July.

7.2.3 Barometric Pressure

The annual mean station barometric pressure for FY91, 24.69 inches of mercury (in. Hg), was almost identical to long-term normals. All months followed the normals quite closely. The maximum monthly average was 24.88 in. Hg in August, and the minimum monthly average was 24.46 in. Hg in March.

7.2.4 Solar Radiation

The solar radiation values included evening values to show the increase in solar radiation in the spring and summer due to the length of the days. The annual mean solar radiation for FY91 was 0.33 langleys per hour (ly/hr). This value was higher than that of FY89 (0.24 ly/hr) and FY90 (0.29 ly/hr). Values were slightly higher in the summer and lower in the winter. The maximum monthly average was 0.44 ly/hr in June and July, and the minimum monthly average was 0.19 ly/hr in January. The RMA area generally has an abundance of sunshine throughout the year, as was evident in FY89 and FY90.

7.2.5 Precipitation

Precipitation for the FY91 period from October 1, 1990, through September 30, 1991, totaled 16.16 inches (or 0.85 inches above normal) at RMA, compared with the climatological mean of 15.31 inches. During the colder seasons, precipitation was primarily in the form of snow. The heaviest monthly precipitation total, 5.01 inches, was measured during August. The month of May generally records the heaviest precipitation, with a long-term mean of 2.47 inches and an all-time maximum of 7.31 inches. However, in FY91, summertime heavy precipitation events accounted for higher levels in August; several storms were intense and stagnated over the area, allowing the majority of the monthly precipitation to be recorded over a few days. The rest of the FY91 monitoring period was normal to drier-than-normal. The driest month was February, with no precipitation (0.00 inches).

7.2.6 Winds

Hourly mean wind speeds for the entire CMP FY91 program averaged 8.7 mph compared to a 30-year climatological mean value (at Stapleton Airport) of 8.8 mph. This close comparison is important because pollutant levels, especially those associated with dust particles (i.e., TSP, PM-10, metals, and SVOCs), are sometimes generated by high wind speeds. The data show that FY91 mean wind speeds were close to average for all months. The maximum monthly average was 10.9 mph in March and May, and the minimum monthly average was 7.1 mph in August. The maximum gust, 62.0 mph, was recorded in May. The predominant wind direction for the RMA in FY91 was southerly, compared to the Stapleton Airport 30-year record of southerly winds. In FY91, RMA had a predominantly southerly or south-south-westerly winds for all months. During FY89 and FY90, predominant winds were more variable from month-to-month; however, the long-term normal was southerly.

There were similarities between the 5-year seasonal and annual wind roses for Stapleton Airport and the corresponding wind roses for the CMP FY91 monitoring periods shown in Figures 7.2-1 through 7.2-5. The CMP FY91 wind roses showed tendencies for strong southerly and south-southwesterly to north-northeasterly flows, whereas, the most common flow pattern at Stapleton Airport is south to north. The secondary tendency was north-northeasterly flow at RMA, compared to the long-term normal northerly flow. Therefore, the FY91 wind patterns were close to normal patterns in all directions.

7.2.7 Atmospheric Stability

Atmospheric stability is an important parameter relating to the dispersion of air pollutants. Along with wind speed and wind direction, it is a key parameter in air quality dispersion models and reflects the potential for the atmosphere to diffuse pollutants horizontally and vertically. Table 7.2-1 shows the percent occurrence for all atmospheric stability categories (A through F) for the CMP composite data set during the monitoring period. A full joint frequency distribution (JFD) of wind speed, wind direction, and stability is provided in Appendix I. Categories A, B, and C, indicate good dispersion ("unstable" conditions) and occur primarily during midday and afternoon periods, and most often in the warmer seasons. These categories were measured 13.6,

7.7, and 9.6 percent of the time, respectively, or a total of 30.9 percent of the time. Categories E and F, reflect poor dispersion ("stable" conditions) and occur during morning hours and more often in the colder seasons. These categories were measured 13.6 and 9.2 percent of the time, respectively, or a total of 22.8 percent of the time. The remainder of the cases measured, 46.3 percent, were in category D, which reflects neutral atmospheric or moderate to strong wind conditions (a frequent occurrence at RMA). Generally dispersion conditions in the D category are good although, as noted in this report, strong winds also have the potential of increasing the emissions of dust-associated particles.

Another indicator of stability is the temperature difference between the 10-meter and 2-meter levels. Greater average temperature differences were recorded in the colder seasons (more stable), compared to smaller differences in the summer (more unstable or neutral).

The stability data for FY91 appear to be typical for the Denver area. The inversion conditions associated with poor dispersion categories E and F were less frequent during the spring and summer, and occurred primarily in the evening and early morning periods. During the winter, there were many inversion periods that lasted continuously for several days and intensified the brown cloud over the Denver area. During spring and summer, the dispersion potential was more typically bimodal, with excellent dispersion during the day and poor dispersion at night.

7.3 SEASONAL AND DIURNAL INFLUENCES

Dispersion characteristics are closely related to diurnal cycles in atmospheric stability and wind patterns. During the day, when dispersion conditions are good (categories A, B, and C), winds are highly variable and frequently gusty. At night, when the inversions set in and dispersion is poor (categories E and F), winds are generally light and follow a drainage pattern from south to north. The seasonal drainage influence is reflected in monthly stability distributions (Table 7.2-1). For example, stable categories E and F occurred 34.8 percent of the time in December and 26.6 percent of the time in June, during FY91. Nevertheless, drainage can be expected in all seasons of the year. These patterns are also reflected in seasonal and annual FY91 RMA and long-term (5-year

Stapleton Airport) wind roses for separate periods of the day, as illustrated in Figures 7.3-1 through 7.3-5. The south-southwesterly flow experienced at RMA during FY91 is evident. All seasons resemble one another, which is typical of the Denver area. The FY91 RMA diurnal wind roses show a predominance of south-southwesterly flows during the midnight to 8:00 A.M. period. From 8:00 A.M. to noon there was a slight transition, but southwesterly flows still prevailed; from noon until 8:00 P.M., however, winds were highly variable, with perhaps a slight predominance of easterly flows: The 8:00 P.M. to midnight period was a transition period, with the winds beginning to shift from southeasterly back to southerly and south-southwesterly.

The representativeness of the FY91 diurnal wind patterns is illustrated by a close comparison with the long-term diurnal wind roses. FY89 and FY90 diurnal wind roses were also comparable to the long-term diurnal patterns.

7.4 SUMMARY AND CONCLUSIONS

Although mean weather patterns change from year to year, it appears that the FY91 meteorological data, with minor differences, were representative of long-term data and provide a useful instrument for assessing contamination impacts during this period and for future remedial progress evaluations. Table 7.4-1 provides a comparison of FY91 meteorological parameters with those of FY90 and FY89. The only differences of note were: a shift in the predominant wind direction from southerly in FY89 to south-southwesterly in FY90, and back to southerly in FY91; a maximum wind gust of 72.5 mph in FY89, compared to 52.8 mph in FY90, and 62.0 mph in FY91; and a solar radiation level of 0.24 ly/hr in FY89, compared to 0.29 ly/hr in FY90 and 0.33 ly/hr in FY91. The solar radiometer was out of operation for a period during the summer of 1989, which may account for the annual differences for that parameter.

The data also suggest important guidelines for mitigation that may be appropriate during remedial activities. Emissions from daytime activities would contribute lesser impacts than evening and early morning activities, because there are better and more variable dispersion conditions during the day. At night, inversions are prevalent and dispersion conditions are poor. Also, winds at night are channelled north and northeast of the remediation source. A factor that should be taken into account, therefore, is the

distance from a remediation source to sensitive areas north of RMA, such as public roads and residential areas beyond RMA boundaries. However, dispersion potential apparently decreases significantly with distance from a ground emissions source and depends upon meteorological conditions.

In this section, typical impacts were inferred based on seasonal and diurnal meteorology. For real-time applications, or for short-term and long-term assessments, these influences must be incorporated into atmospheric dispersion models along with detailed source emission characteristics. Model approaches employed in the present report and recommended for future remedial progress evaluations are discussed in Section 7.6.1.

7.5 RMA METEOROLOGICAL STATION COMPARISONS

During FY91, a special comparison was made between the data compiled at the four meteorological stations operating at RMA. Figure 1.2-1, previously shown, indicates the locations of these stations. In general, the terrain across RMA is fairly uniform. Nevertheless, there are slight differences in elevation and surrounding topography that could affect air quality dispersion characteristics on certain occasions. The highest station, M4, 15 located on the crest of a knoll with an elevation of 5,278 ft. The lowest station, M1, is located just east of the old Basin F and has an elevation of 5,192 ft. Located to the north of North Plants, M2 has an elevation of 5,193 ft. and is separated from M1 by a higher topography. Located southeast of Basin A and northeast of the South Plants, M3 has an elevation of 5,263 ft. The channelling of winds around topography and temperature differences, due to drainage and elevation differences, explains most of the variation between the sites.

Tables 7.5-1 through 7.5-4 provide a comparison of the four stations for wind speed and direction, temperature, precipitation, and atmospheric stability from January (when the meteorological program under CMP was re-initiated) to the conclusion of the FY91 period in September 1991. It should be noted that certain periods of data are missing or invalid due to improper calibrations or tower work. These data were not included in the data summaries. Also, the temperature sensor at M1 has a tendency to be slightly warmer, due to the sensor construction. Table 7.5-2 indicates temperatures at M1 were

an average of 1°F higher than M2, M3 and M4. Overall, only minor differences were noted between these stations.

The highest average FY91 wind speed, 8.8 mph, occurred at M1. The lowest average FY91 wind speed, 7.2 mph, was recorded at M3. Average FY91 wind speeds at M2 and M4 were 8.2 and 8.7 mph, respectively. The predominant wind direction at all stations was from the south.

Average temperature differences between each station were consistently within 1°F. Although M1 reported the highest daytime average maximum temperatures, M2 and M3 generally reported the lowest evening average minimum temperatures. These three stations have the lower elevations, and the temperature differences widely reflect the exposure and radiation characteristics of the sites. Drainage at night may have caused the lower evening temperatures at M2 and M3.

Precipitation was variable from station to station, especially during the spring and summer months, when thunderstorm and shower activity were highly variable across RMA. The highest FY91 annual precipitation, 16.16 inches, was recorded at M4. Compilation of monthly precipitation totals from the four sites is presented in Table 7-6.

Joint frequency distributions of wind speed and wind direction for FY91 for the four monitoring stations are provided in Appendix I. Table 7.5-4 summarizes these distributions and provides the frequency of atmospheric stability categories for each site. (This is a principal parameter in air quality dispersion prediction.) Again, only minor differences are evident. Stability categories at the sites were fairly closely distributed, although category D (neutral) occurred more frequently and category A (very unstable) occurred less frequently at M3.

A conclusion of this evaluation is that for long-term and broad assessments, the differences between the four RMA meteorological monitoring sites are not significant. However, for short-term or day-to-day assessments, such as real-time remedial activities or emergency alerts, significantly different air quality dispersion patterns could be identified at specific RMA locations under the four-tower network.

Potential downstream impacts from each of the four site locations would have been in different directions. These differences between sites are averaged over the long-term and are considerably less evident; however, for short-term or real-time evaluations, the differences are highly significant.

7.6 ATMOSPHERIC DISPERSION MODEL

7.6.1 Model Approaches

One of the objectives of the CMP is the identification of atmospheric conditions that may trigger high contamination levels and may require special precautions and mitigating actions. A related task is the development and/or application of air dispersion prediction techniques and models that use available site data and provide forecasts of potential contamination impacts. The Basin F program developed and applied such modeling techniques as an integral part of its program to provide for the health and safety of workers and the general public. The CMP closely coordinated these operational activities and incorporated dispersion model results into previous reports as well as the present report. These techniques appear to be effective and are recommended for future remedial and air quality assessment applications. Specific models used in remedial operations and in data assessments are discussed below.

The models employed were the EPA Industrial Source Complex (ISC) Model (USEPA 1986a) and the PUFF Advection Model (INPUFF2) (USEPA 1986b). These are standard and approved EPA models used for general purposes to predict air quality impacts. They are often used in environmental impact statements and in air quality permit applications. For Basin F remedial activities, they were modified to support the cleanup operations, and in particular, to use real-time air quality and meteorological data.

Because precise measurements of source emissions could not be determined, a unique approach was devised to use X/Q values, in conjunction which measured ambient concentrations, to predict short-term (operational) and longer-term (assessment) impacts. The X/Q values, as noted in previous discussions relating to the CMP and Basin F monitoring results, do not indicate ambient concentrations, but rather, indicate relative

strength or potential concentration levels, based on meteorological conditions and on an undetermined emission source strength. In the Basin F program, the X/Q values were calibrated with real-time monitoring data to predict ambient concentrations in support of the remedial operations. Appendix K documents basic features of the EPA Puff Advection and ISC Models. In Gaussian dispersion models, the ground-level concentrations of contaminants in a plume can be computed by:

$$X = \frac{Q}{\pi \sigma_y \sigma_z u} \cdot \exp\left[-1/2\left[\frac{ESH}{\sigma_z}\right]^2\right]$$

Where
- X = predicted ground-level concentration
- Z = source emissions
- σ_y = horizontal dispersion coefficient (function of distance from source)
- σ_z = vertical dispersion coefficient (function of distance from source)
- u = mean wind speed at plume level
- ESH = effective stack height, or plume height level assumed for Basin F application

When the source emission term is not determined, the equation can be written as follows:

$$X/Q = \frac{1}{\pi \sigma_y \sigma_z u} \cdot \exp\left[-1/2\left[\frac{ESH}{\sigma_z}\right]^2\right]$$

For the present assessment applications, assuming that Q is constant or near constant (at any given time), the relationship between an observed (monitored) concentration (at a specific grid location where an X/Q was calculated) and at another unmonitored location (where an X/Q was also determined) was the ratio between the two values. This was a very simple approach, but was highly effective in determining the spread of a dispersion plume beyond and between the monitoring networks. This technique will allow for the prediction of future concentrations during ongoing operations, assuming that emissions do not significantly change during a particular operation. As remedial

progress continues and emissions are eventually reduced, observed concentrations for a specified X/Q should also be reduced. Thus, the model has the potential to evaluate remedial progress under comparable meteorological and air dispersion conditions.

The PUFF Advection model was used primarily for short-term predictions at Basin F in conjunction with real-time operations. Air monitoring was conducted using photoionization detector (HNu), organic vapor analyzer (OVA), ammonia, and dust monitors at various remedial activity areas and along the Exclusion Zone perimeter. Perimeter readings were taken at four fixed locations and also downstream from Basin F, based on the prevailing wind, where maximum concentrations were anticipated. Concurrent with each monitoring reading, the PUFF Advection Model was run to determine the trajectory of the contamination plume. The X/Q values of the model were then immediately matched with actual monitored data to determine the potential distribution of the plume trajectory and the likelihood of Level B exceedances outside the protected areas. A maximum limit of 1 ppm was established for expansion of the Exclusion Zone and/or evacuation of personnel without protective clothing and equipment.

Both the PUFF Advection Model and the ISC Model have the capability to provide longer-term X/Q dispersion assessments. The PUFF Advection Model operates on 15-minute trajectories, it takes much longer to run; however, the PUFF Advection Model can be used to assess longer-term episodes if more refined or sensitive analyses are required. The ISC Model was primarily employed for 24-hour assessments and beyond.

The results of the CMP and Basin F monitoring programs, discussed in Section 4, were compared with dispersion analyses obtained from the EPA ISC Model. As noted, their evaluations provided highly useful information for associating dispersion patterns and meteorological conditions with observed and potential air contamination levels. When a distinct source was evident, such as Basin F, Basin A, or the South Plants, the model identified the spread of the dispersion plume downstream from the source. The concurrent monitored data then provided a mechanism for calibrating and projecting ambient concentrations throughout RMA and beyond its boundaries. The model identified worst-case meteorological conditions and seasonal and diurnal effects, thus providing a basis for mitigation actions. For future assessments, it provides a basis for

evaluating remedial progress by ensuring that monitoring results are compared to similar worst-case meteorological and seasonal conditions.

The effectiveness of model applications is evident from the data and comparisons given in the preceding sections. The impacts from known RMA sources, or remedial activities, have been identified. The relative strength of these impacts, with distance from the source, have also been quantitatively determined. There is a considerable scattering of X/Q values at specific site locations, which can be attributed to many factors beyond the simplified model's present capabilities. These include: variations in source emissions and remedial production activity, both of which obviously result in variations in source concentration levels downwind from the source; the existence of other potential area and local sources, which present a noise factor in the database; short-term meteorological influences that are not integrated into the hourly ISC database (this suggests the special advantage in using the short-term PUFF trajectories); and the general complexity of the dispersion process that is not entirely identified in the model.

In summary, the PUFF Advection and ISC Models, using the X/Q calibration approach, were and will continue to be workable vehicles for projecting contamination levels during remedial activities and for assessing remedial progress. It is not the purpose of the CMP to do extensive research investigations to improve model validation and applications. Nevertheless, several practical follow-up approaches may be applied in future CMP evaluations that would not only improve the models but would also provide considerable insight into the general assessment of RMA contamination levels during subsequent remedial activities. These additional approaches are discussed below.

7.6.2 Additional Model Approaches and Analyses

7.6.2.1 Source Emissions Characterization

The standard dispersion model predicts ambient concentrations based upon meteorological factors and a known, or estimated, emission source. The Basin F real-time application, and the CMP have, to a certain extent, effectively bypassed the emissions term and substituted a mechanism (X/Q values) for providing contamination levels based upon concurrent monitoring data. More precise data on emission releases

at potential RMA and off-site contamination sources will add an additional dimension to the modeling and prediction capabilities. Data indicating the combination of emission levels, meteorological factors, and resultant ambient concentrations will also allow for further refinements of the model. For subsequent cleanup activities at RMA requiring air quality impact assessments, precise emissions data and characterizations will enhance prediction capabilities.

7.6.2.2 Remedial Activity Production Data

It is evident from the Basin F monitoring results during remedial operations, and from the Remedial Investigation Program results obtained prior to remedial operations, that the cleanup activities resulted in increases in some of the monitored pollutants, in particular: TSP, pesticides, organic compounds, and some metals. It may be assumed that these increases were a direct consequence of and proportional to the extent of remedial efforts on a day-to-day basis. Various information pertaining to the status and intensity of cleanup operations (including the tons of soil and sludge removed and hauled each day, the type and number of vehicles and equipment employed, the type and number of storage areas and uncovered waste pile areas, the number of gallons of liquid transported, and any other emission-producing factors related to operations) would be especially useful in assessing relative emissions potential and in refining model prediction capabilities. These data were available, to a limited extent, during the Basin F operations, but not necessarily on a real-time basis; this made it difficult to interpret the cause of higher contamination events and the extent of mitigation efforts that were needed. It should be noted that many industrial real-time air quality prediction systems are directly related to production factors, and this approach would have equally valid application for waste cleanup operations.

7.6.2.3 Local and Regional Emissions Inventory

One of the difficulties in analyzing the CMP and Basin F data was that there were obviously other off-site, local and regional air emissions sources in the RMA vicinity that contributed to air pollution levels measured at RMA monitoring sites. As noted in the data evaluations, metropolitan Denver was a source of TSP, PM-10, some metals, gaseous criteria pollutants, and undoubtedly, certain organics. Also, various industrial

sources and farming areas in north Denver, Commerce City, and Adams County may have contributed to organics and other potential contaminants. Many of these sources have been identified to facilitate evaluation of their contribution to RMA baseline data. Unless these sources are properly identified, they can present an unknown factor in the dispersion model prediction evaluations of potential RMA contamination and remedial impacts. Therefore, a complete inventory of local off-site sources is recommended for the interpretation of baseline data and remedial progress at RMA. Work has begun on this effort, and an inventory of known sources is included in this report in Section 5.7. These data contribute to the overall analyses. Additional work is also required in identifying the contributions and impacts of metropolitan mobile sources on RMA monitoring results. Again, quantification of such influences would enhance model evaluations and prediction capabilities. Much of this information is available in the CDH files, the EPA's Air Toxics Study for Denver, and other reports, including the Citizens Report on Toxic Pollution in Colorado (see Section 4.0).

7.6.2.4 Empirical/Statistical Adjustments

A final approach for model improvement is the application of empirical techniques and pertinent, or unique, physical relationships to improve model capabilities. For example, it is generally agreed that organics are released into the atmosphere at warmer temperatures and also under certain favorable air pressure conditions and TSP, metals, and PM-10 are generally higher after certain threshold wind gust levels are achieved. Also, very localized, topographic, site-specific characteristics, which are not considered in the dispersion model, may be evident in the spread of potential air contaminants over the area. The database now being collected provides a mechanism for establishing some of these influences; some have already been identified in the present report. It is anticipated that this effort will continue and, if possible, validated relationships will be incorporated into model applications.

TABLE 7.1-1

SUMMARY OF RMA METEOROLOGICAL MONITORING DATA RECOVERY FOR FY91

Parameter	Annual % Recovery	Contract Period % Recovery
Wind Speed	86.5	100.0
Wind Direction	86.5	100.0
Sigma Theta	86.5	100.0
Temperature	86.5	100.0
Relative Humidity	79.1	94.8
Barometric Pressure	86.4	100.0
Solar Radiation	79.2	94.0
Precipitation	82.2	89.5
Maximum Gust	86.5	100.0
Temperature Difference (10 m - 2 m)	75.6	86.5
Stability	86.5	100.0
Program Total	83.8	96.8

TABLE 7.2-1

SUMMARY OF ROCKY MOUNTAIN ARSENAL MONTHLY METEOROLOGICAL CONDITIONS FOR FY91 (OCTOBER 1, 1990, THROUGH SEPTEMBER 30, 1991)

		Temperature (°F)								Precipitation (inches)		
	Month	Avg. Max	Avg. Min	Extra Max	Extra Min	Mean	Mean Relative Humidity	Mean Station Pressure (in.Hg)	Mean Total Daily Solar Radiation (Ly/Hr)	Total	Max 24-Hr	# of days
1	Oct	64.2	40.0	82.8	27.0	51.5	48	24.74	0.23	0.57	0.18	5
2	Nov	45.7	24.1	58.6	18.5	36.1	ND	ND	ND	0.04	0.03	2
3	Dec	36.4	14.4	66.6	-23.2	24.5	ND	24.69	ND	0.14	0.05	3
4	Jan	38.0	18.3	55.8	-2.2	28.0	56	24.69	0.19	0.06	0.06	1
5	Feb	51.2	30.2	62.5	14.7	39.8	44	24.64	0.21	0.00	0.00	0
6	Mar	52.7	31.6	67.9	19.4	42.3	42	24.46	0.30	0.23	0.14	2
7	Apr	55.9	36.4	79.4	19.4	46.1	53	24.53	0.32	1.00	0.28	6
8	May	70.0	48.0	84.3	31.2	58.4	55	24.55	0.42	3.08	0.92	8
9	June	79.9	56.5	96.0	50.4	67.8	46	24.71	0.44	2.83	0.76	15
10	July	83.3	60.8	93.1	54.9	71.5	41	24.85	0.44	2.22	1.09	11
11	Aug	81.3	59.8	90.4	55.7	69.7	51	24.88	0.38	5.01	1.17	7
12	Sept	73.7	48.7	84.2	37.6	61.3	56	24.83	0.34	0.98	0.17	8
13	Year	61.0	39.1	96.0	-23.2	49.5	49.2	24.69	0.33	16.16	1.17	68

TABLE 7.2-1

SUMMARY OF ROCK MOUNTAIN ARSENAL MONTHLY METEOROLOGICAL CONDITIONS FOR FY91 (OCTOBER 1, 1989, THROUGH SEPTEMBER 30, 1991) (Concluded)

		Wind Speed (MPH)					Atmospheric Stability Category (% occurrence)					
	Month	Mean Speed	Maximum Speed	Maximum Gust	Predominant Wind Direction	Average Temp Diff	A	B	C	D	E	F
1	Oct	8.5	25.1	38.2	South	1.3	9.9	5.9	7.7	47.8	17.7	11.1
2	Nov	10.0	22.0	ND	South	ND	7.9	7.0	5.3	64.0	11.4	4.4
3	Dec	8.1	34.6	ND	SSW	ND	8.9	4.7	7.9	44.9	19.5	14.11
4	Jan	8.7	25.6	38.1	SSW	2.7	8.4	2.8	6.4	55.8	14.9	11.2
5	Feb	7.9	25.9	37.8	SSW	2.0	9.4	7.8	6.3	46.7	19.9	10.0
6	Mar	10.9	35.8	45.5	South	0.9	10.4	6.6	8.6	58.9	8.2	7.4
7	Apr	9.1	28.2	42.0	SSW	0.6	11.4	8.2	11.8	49.0	11.7	7.9
8	May	10.9	38.4	62.0	South	0.5	13.9	7.9	13.2	51.4	7.8	5.9
9	June	8.4	28.7	42.4	SSW	1.4	20.1	9.6	10.4	38.9	9.2	11.8
10	July	7.9	26.3	41.8	SSW	2.4	16.3	10.6	13.6	40.3	11.0	8.2
11	Aug	7.1	17.9	50.6	South	1.2	20.7	10.0	9.6	35.8	16.3	7.7
12	Sept	7.7	31.2	37.6	South	1.4	17.9	8.1	7.9	42.9	15.0	8.2
13	Year	8.7	38.4	62.0	South	1.4	13.6	7.7	9.6	46.3	13.6	9.2

Legend:
Maximum Speed = Maximum 1-Hr Average Wind Speed Value for the Month
Maximum Gust = Maximum Instantaneous Wind Speed for the Month
Temp Diff = Temperature Difference (10-meter minus 2-meter) on the Tower
ND = No Data

A = Extremely Unstable
B = Unstable
C = Slightly Unstable
D = Neutral
E = Stable
F = Extremely Stable

Note: There are missing data periods within this table due to the CMP data gap of 10/90 through 1/91.

TABLE 7.4-1

FY89 - FY91 COMPARISON

	FY91	FY90	FY89
Average Maximum Temperature (°F)	61.0	62.0	61.7
Average Minimum Temperature (°F)	39.1	39.9	38.6
Mean Temperature (°F)	49.5	50.6	49.9
Mean Relative Humidity (%)	49.2	52	49
Mean Total Daily Solar Radiation (Ly/Hr)	0.33	0.29	0.24
Total Precipitation (in)	16.16	11.56	12.41
Total Number of Days of Precipitation	68	67	77
Mean Wind Speed (mph)	8.7	8.6	8.5
Maximum Wind Speed (mph)	38.4	35.9	33.2
Maximum Wind Gust (mph)	62.0	52.8	72.5
Predominant Wind Direction	SOUTH	SSW	SOUTH
Atmospheric Stability Class (%)			
A - Extremely unstable	13.6	16.5	16.5
B - Moderately unstable	7.7	4.9	5.2
C - Slightly unstable	9.6	5.7	6.0
D - Neutral	46.3	45.8	46.0
E - Slightly stable	13.6	16.8	15.6
F - Moderately stable	9.2	10.5	10.6

TABLE 7.5-1

METEOROLOGICAL TOWER COMPARISON OF WIND SPEED (MPH)/DIRECTION (DEGREES)

	M1		M2		M3		M4	
	Speed	Direction	Speed	Direction	Speed	Direction	Speed	Direction
AVERAGE								
Jan	8.9	SSE	8.3	S	6.8	SSE	8.4	S
Feb	8.4	S	7.7	S	6.5	S	7.9	SSW
Mar	10.8	SSW	10.0	SSW	8.8	SSW	10.9	S
Apr	9.1	S	8.6	S	7.4	S	9.1	SSW
May	11.5	SSE	10.0	SSE	8.7	SSE	10.9	S
Jun	7.9	S	8.0	S	6.4	S	8.4	SSW
Jul	7.8	S	7.5	SSE	6.3	S	7.9	SSW
Aug	7.3	S	6.8	S	5.5	S	7.1	S
Sep	7.9	SSE	7.2	S	6.0	S	7.7	S
FY91	8.8	S	8.2	S	7.2	S	8.7	S

	M1		M2		M3		M4	
	Speed	Direction	Speed	Direction	Speed	Direction	Speed	Direction
FASTEST GUST								
Jan	38.1	WNW	35.5	WNW	34.0	NNW	38.1	WNW
Feb	37.8	W	38.3	W	35.4	W	37.8	W
Mar	45.5	WNW	43.6	SSE	45.3	W	45.5	WNW
Apr	42.0	SW	37.6	N	39.5	WNW	42.0	SW
May	62.0	SSE	57.9	SSE	67.1	SSE	62.0	SSE
Jun	42.4	S	62.6	SE	46.0	W	42.4	S
Jul	41.8	SSW	47.8	NW	52.1	NNE	41.8	SSW
Aug	50.6	SSE	56.7	SSE	39.7	W	50.6	SSE
Sep	37.6	NNE	41.1	NE	38.5	NNE	37.6	NNE
FY91	62.0	SSE	62.6	SE	62.1	SSE	62.0	SSE

Note: ND - No Data
M - Meteorological Station

TABLE 7.5-2

METEOROLOGICAL TOWER COMPARISON OF TEMPERATURE (°F)(FY91)

	Maximum Temperature				Minimum Temperature				Average Temperature			
	M 1	M 2	M 3	M 4	M 1	M 2	M 3	M 4	M 1	M 2	M 3	M 4
January	50	49	49	50	-1	-5	-2	-2	24	24	24	25
February	64	63	62	63	15	15	15	15	40	39	39	40
March	69	68	68	68	20	20	19	19	43	42	42	42
April	80	79	79	79	21	17	16	19	47	46	46	46
May	85	84	84	84	31	30	30	31	59	58	59	58
June	97	96	96	96	51	50	50	50	69	68	68	68
July	95	93	93	93	28	55	55	55	73	71	72	71
August	91	90	90	90	56	53	55	56	70	70	70	70
September	85	84	84	84	37	36	38	38	62	61	61	61
FY91	97	96	96	93	-1	-5	-2	-2	54	53	53	53

Note: M - Meteorological Station

TABLE 7.5-3

METEOROLOGICAL TOWER COMPARISON OF PRECIPITATION (INCHES)(FY91)

	Monthly Totals			
1991	M 1	M 2	M 3	M 4
JAN	0.00	0.01	0.01	0.06
FEB	0.00	0.00	0.00	0.00
MAR	0.27	0.02	0.48	0.23
APR	1.20	0.63	1.15	1.00
MAY	3.13	1.36	1.98	3.08
JUN	1.55	1.88	2.83	2.83
JUL	3.60	2.45	2.25	2.22
AUG	4.04	2.13	4.67	5.01
SEP	1.08	0.34	1.12	0.98
Annual Total	14.87	8.82	14.49	15.41

Note: M - Meteorological Station

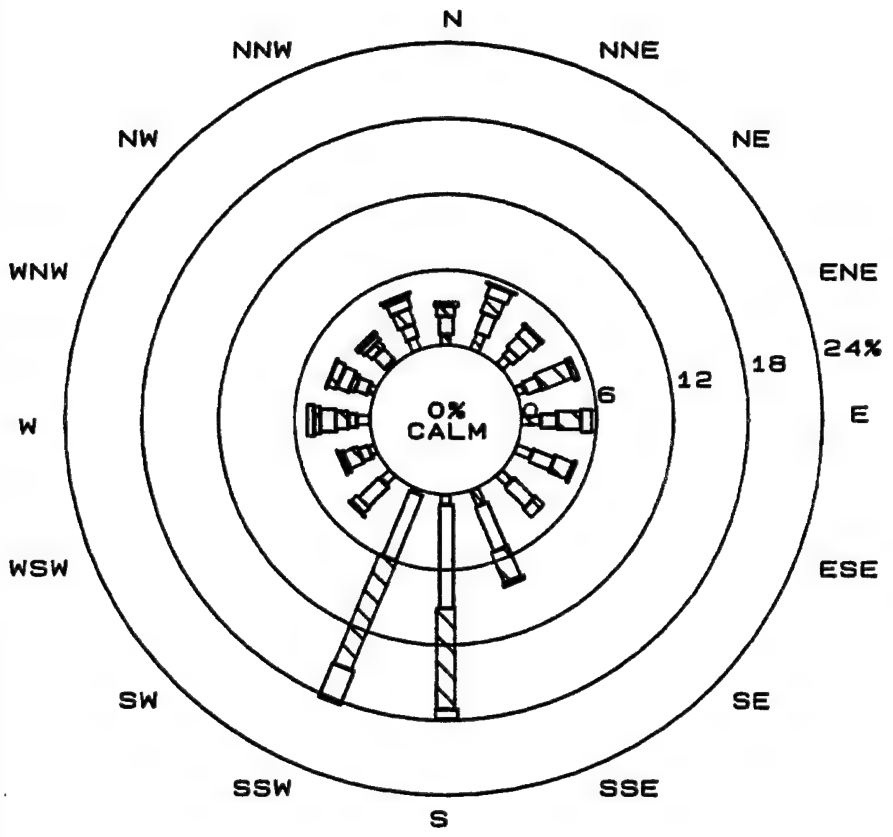
TABLE 7.5-4

PERCENT FREQUENCY OF OCCURRENCE OF ATMOSPHERIC STABILITY CATEGORIES FOR EACH METEOROLOGICAL STATION (FY91)

Stability Category	Frequency (%)			
	M1	M2	M3	M4
A	12.1	14.2	8.5	13.6
B	7.7	8.7	5.7	7.7
C	10.3	10.4	10.8	9.6
D	46.6	44.1	53.6	46.3
E	18.1	15.6	13.1	13.6
F	5.1	7.1	8.3	9.2

Note: M - Meteorological Station

Wind Rose - RMA (Fall FY91) vs Stapleton (Fall 86-90) (Figure 7.2-1)



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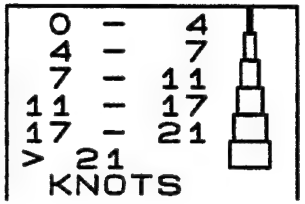
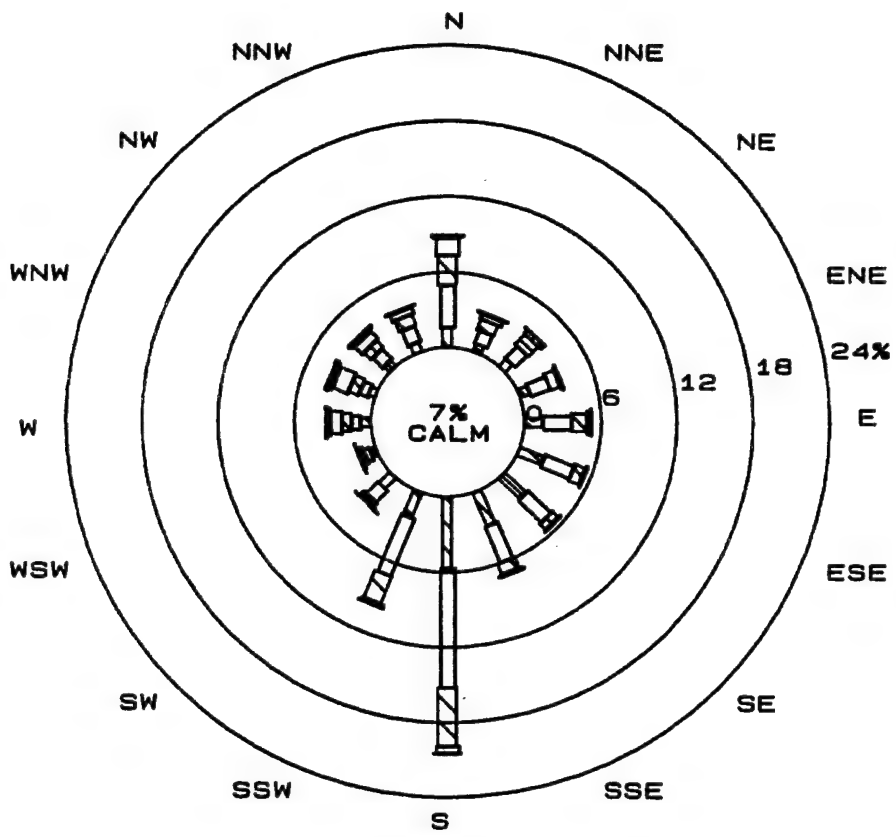
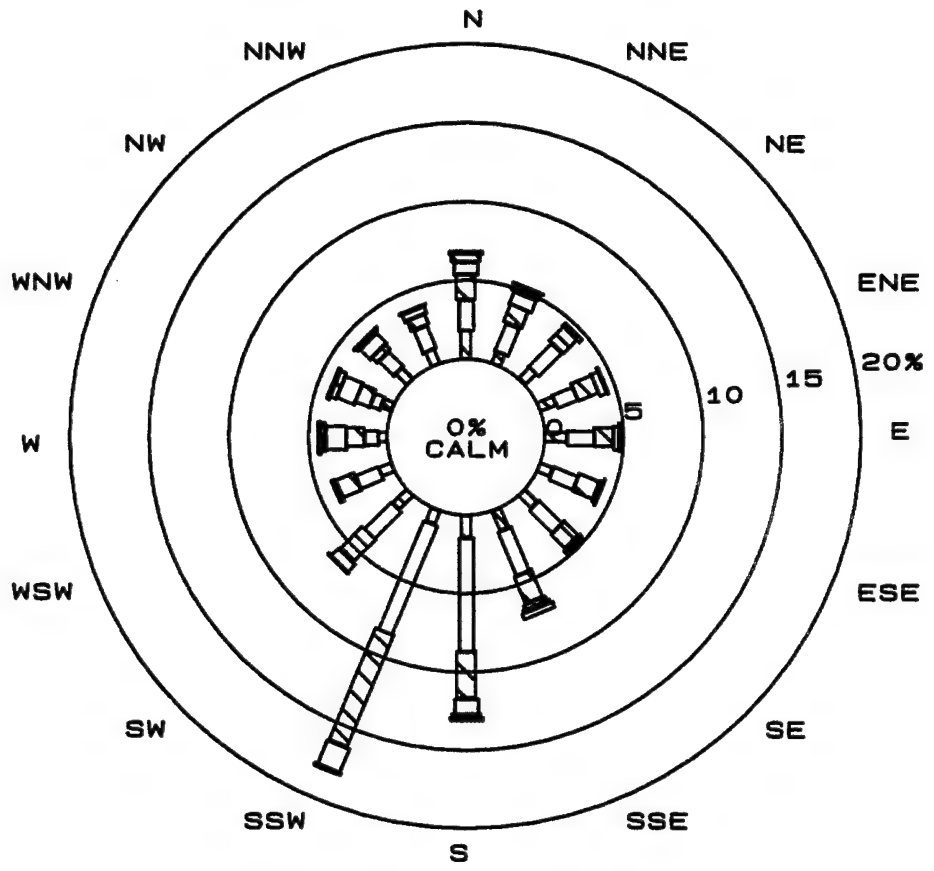
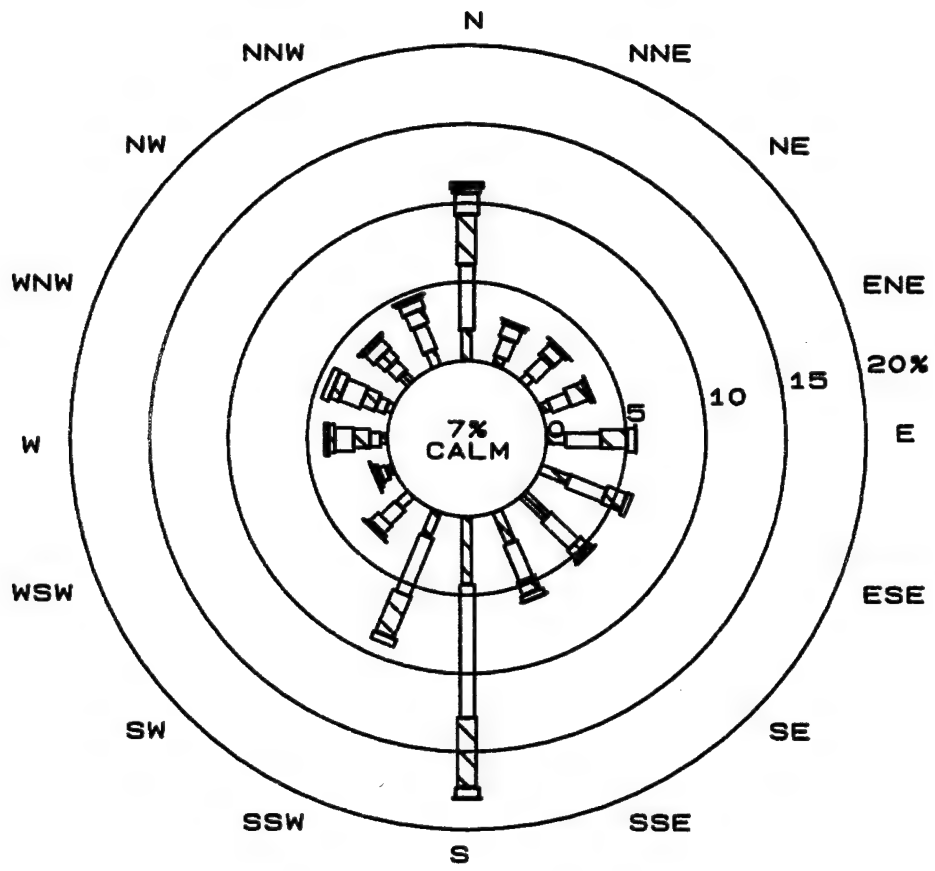




Stapleton Airport

Wind Rose - RMA (Wntr FY91) vs Stapleton (Wntr 86-90) (Figure 7.2-2)





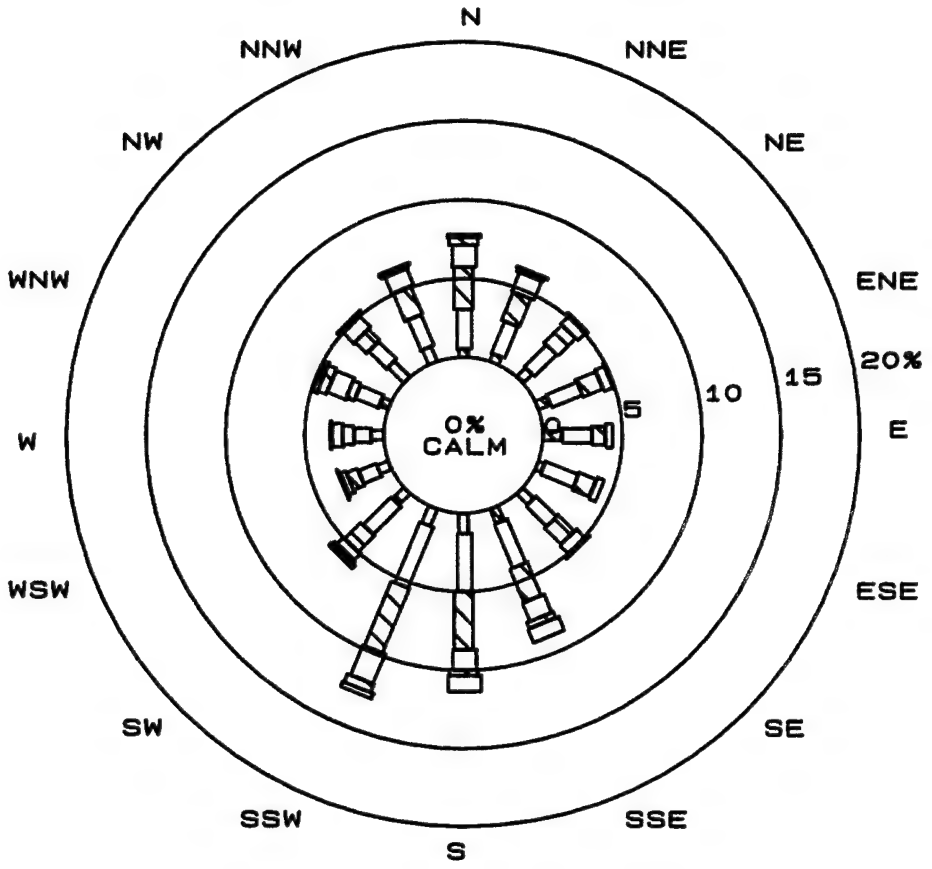
0	4
4	7
7	11
11	17
17	21
>	21

KNOTS

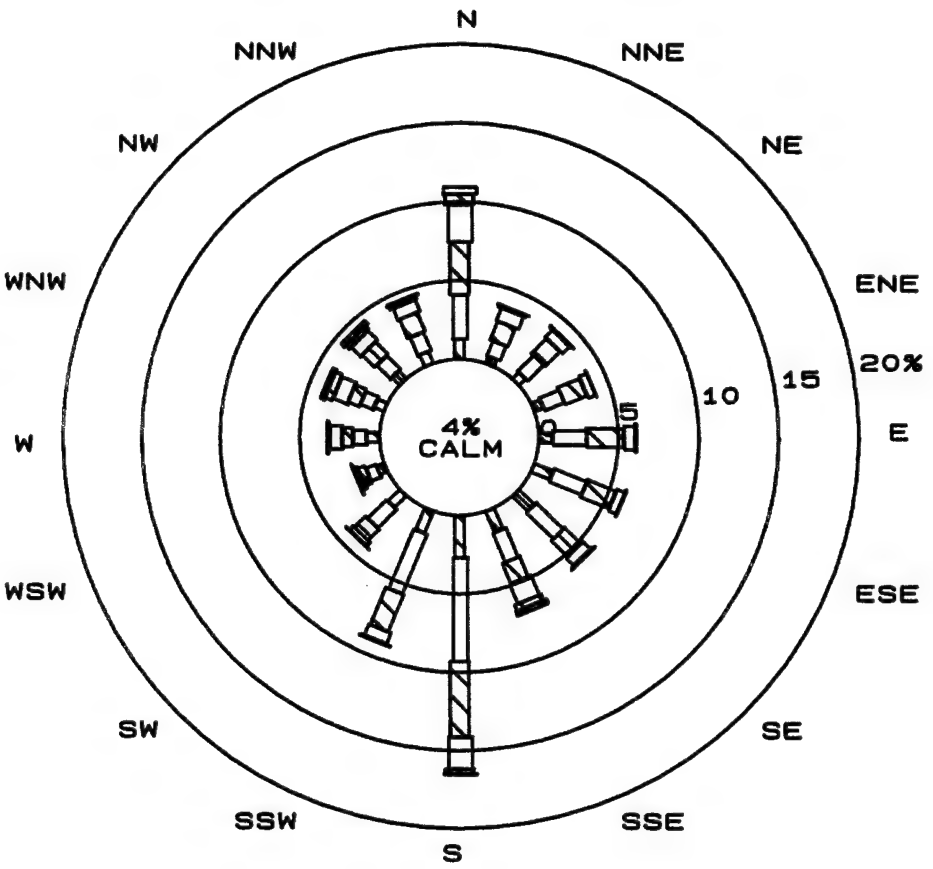
Rocky Mtn Arsenal

Stapleton Airport

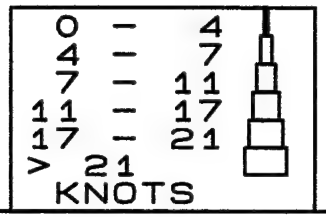
Wind Rose - RMA (Spr FY91) vs Stapleton (Spr 86-90) (Figure 7.2-3)



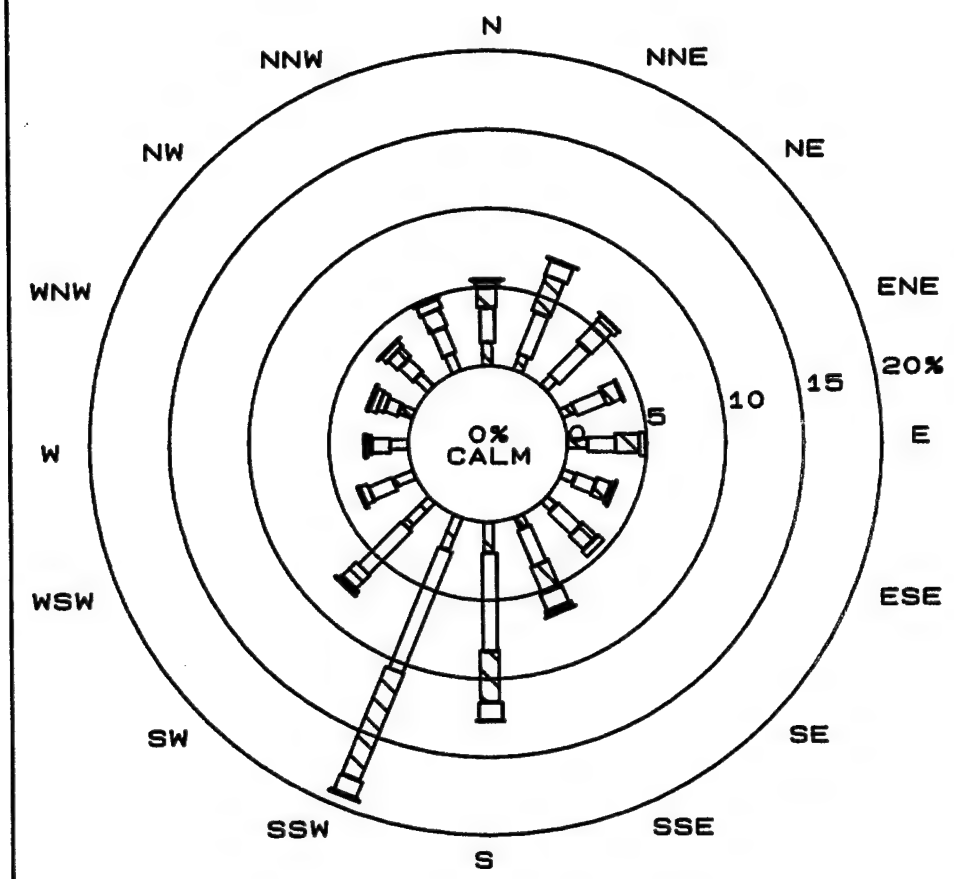
Rocky Mtn Arsenal

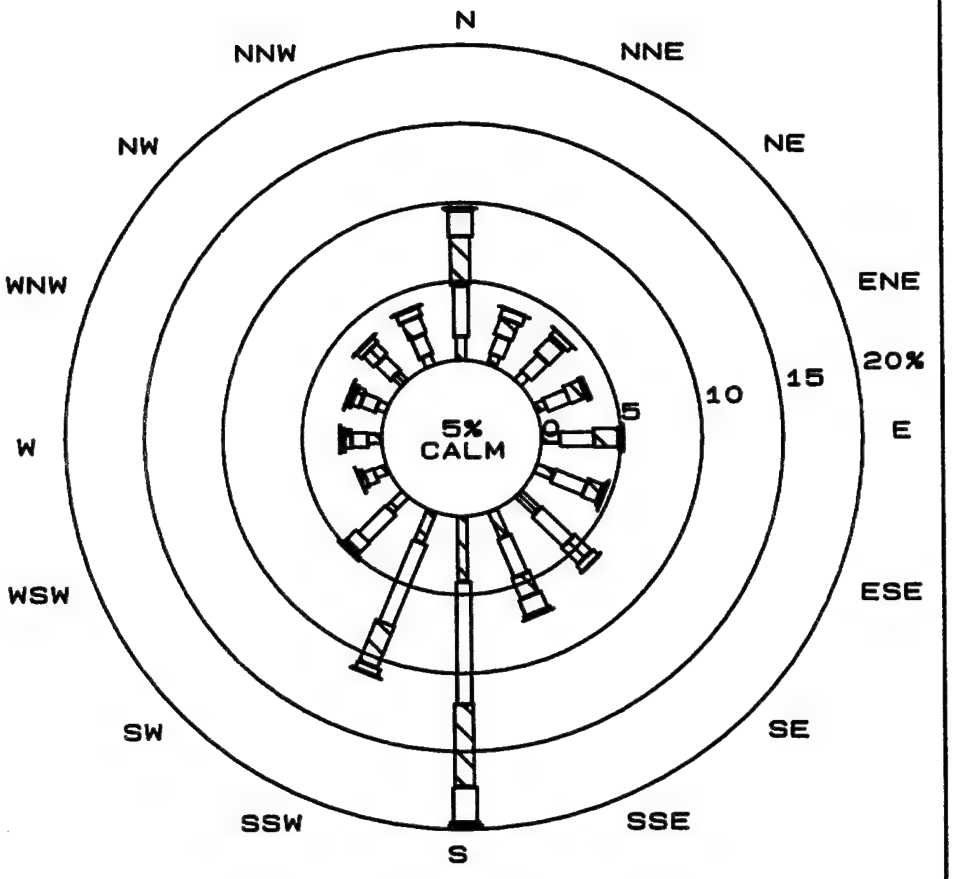


Stapleton Airport



Wind Rose - RMA (Sum FY91) vs Stapleton (Sum 86-90) (Figure 7.2-4)





0 -	4
4 -	7
7 -	11
11 -	17
17 -	21
>	21

KNOTS

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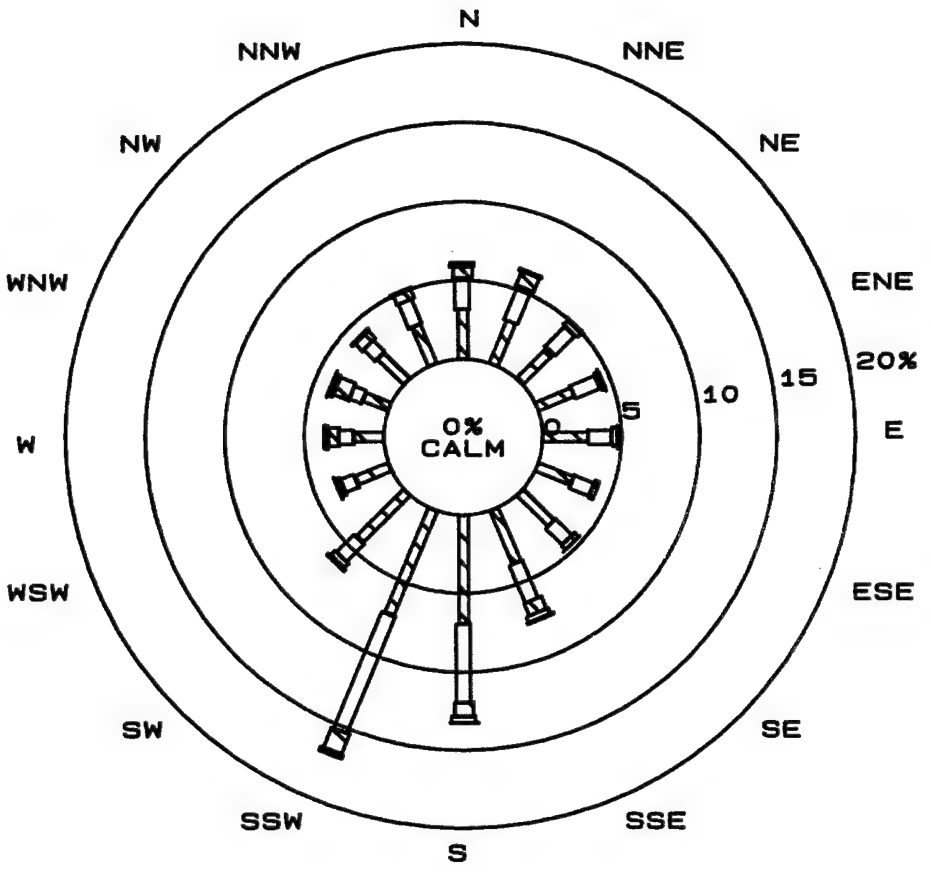
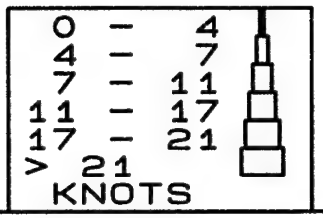
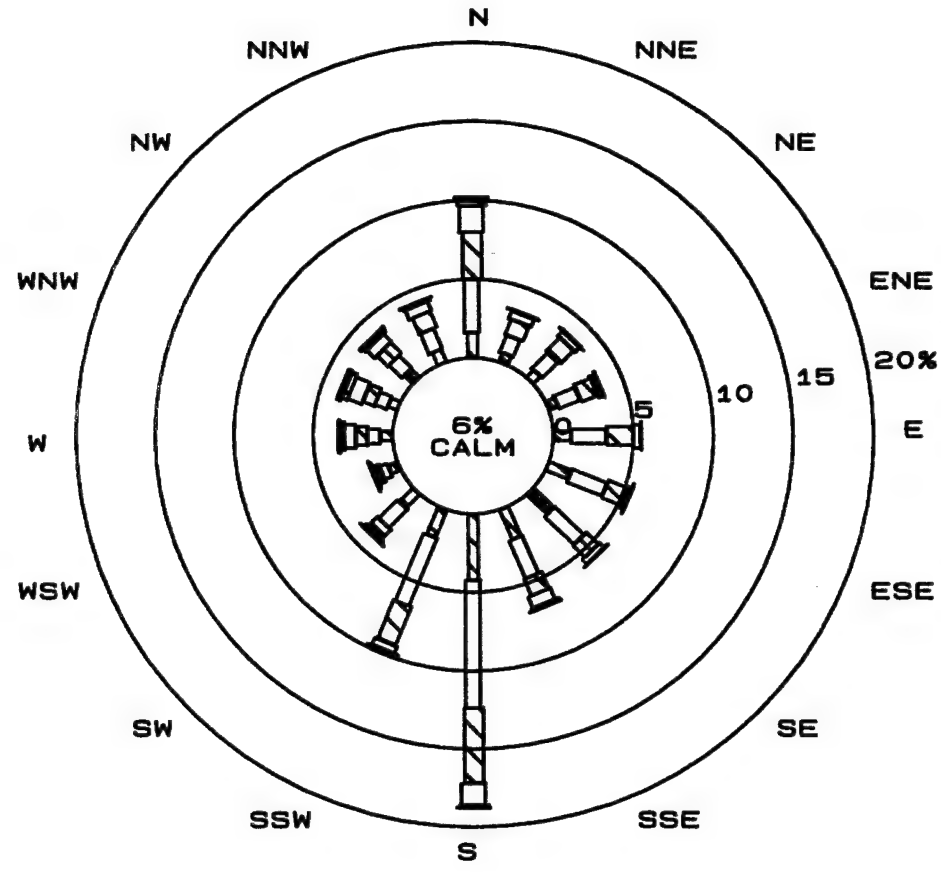
Stapleton Airport

Wind Rose - RMA (Ann FY91) vs Stapleton (Ann 86-90) (Figure 7.2-5)



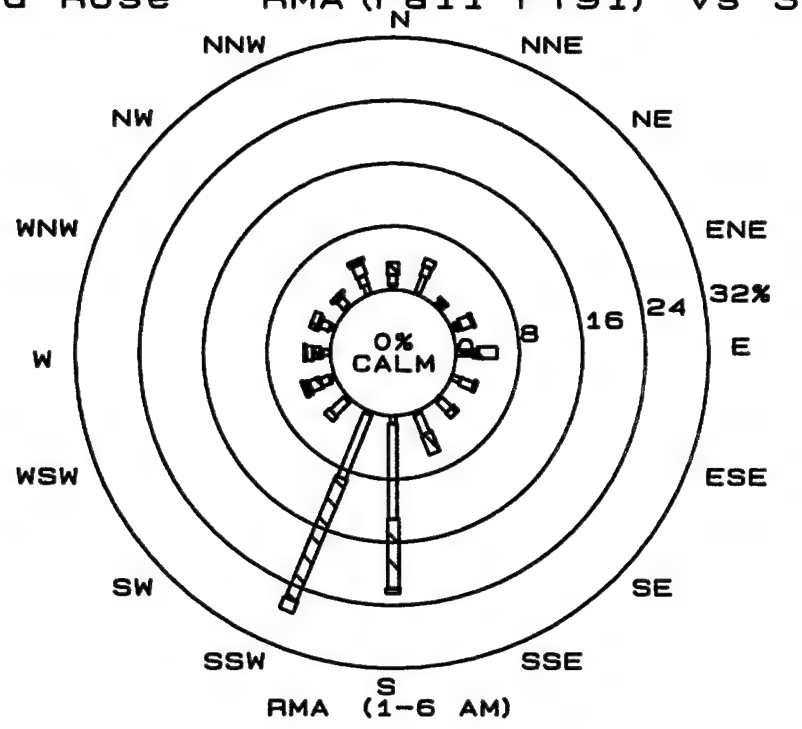
Rocky Mtn Arsenal



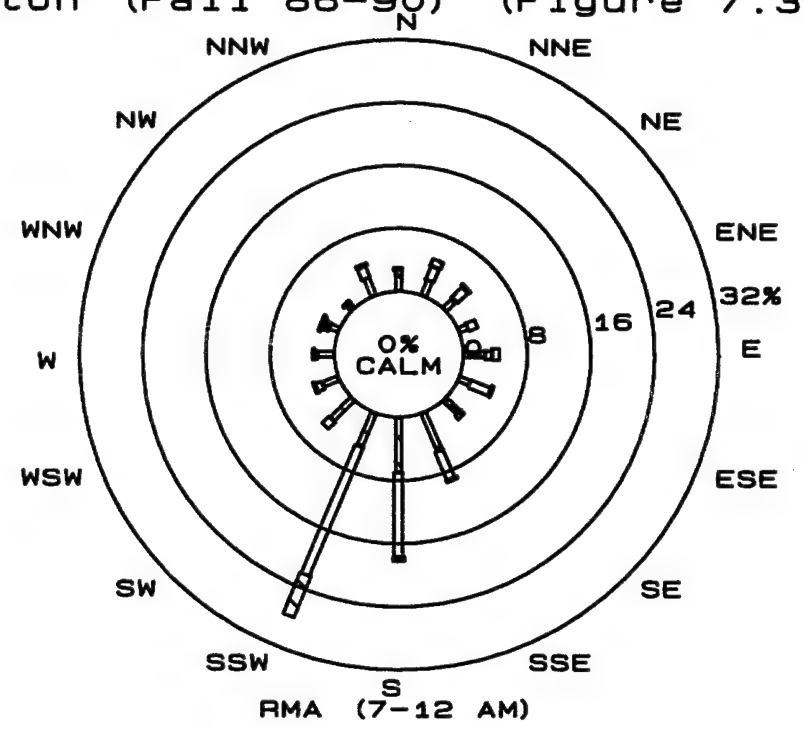


Stapleton Airport

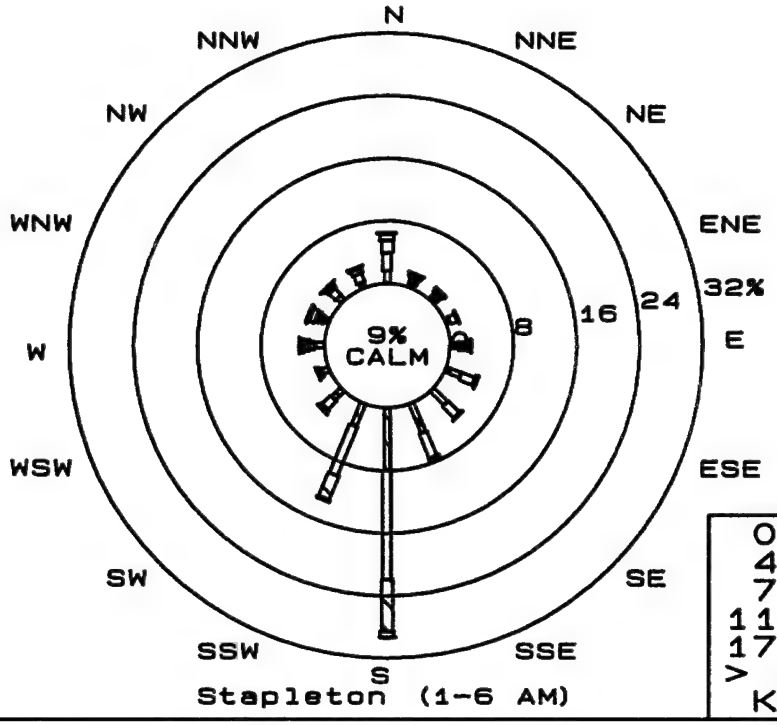
Wind Rose - RMA (Fall FY91) vs Stapleton (Fall 86-90) (Figure 7.3-1)



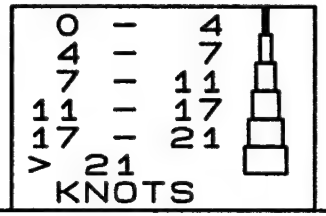
RMA (1-6 AM)

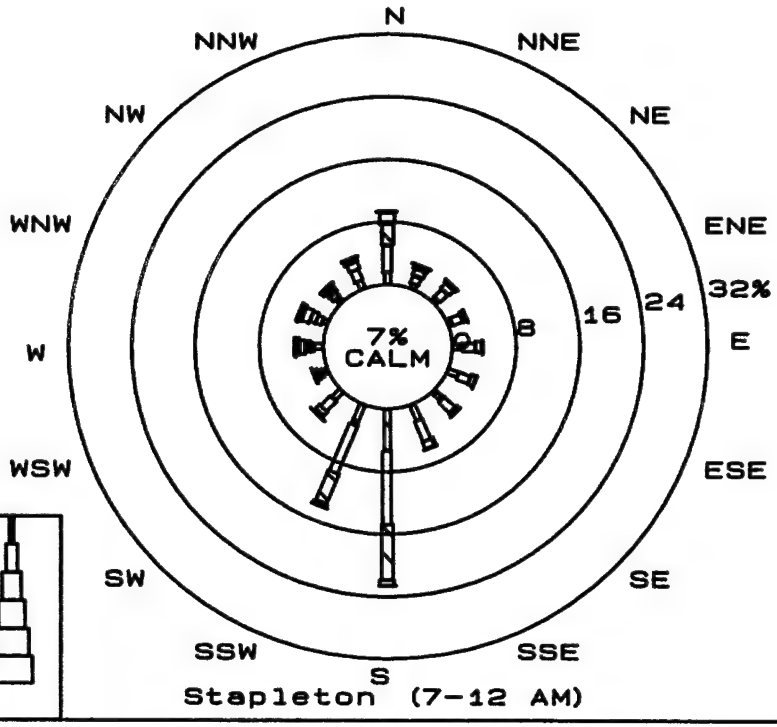


RMA (7-12 AM)



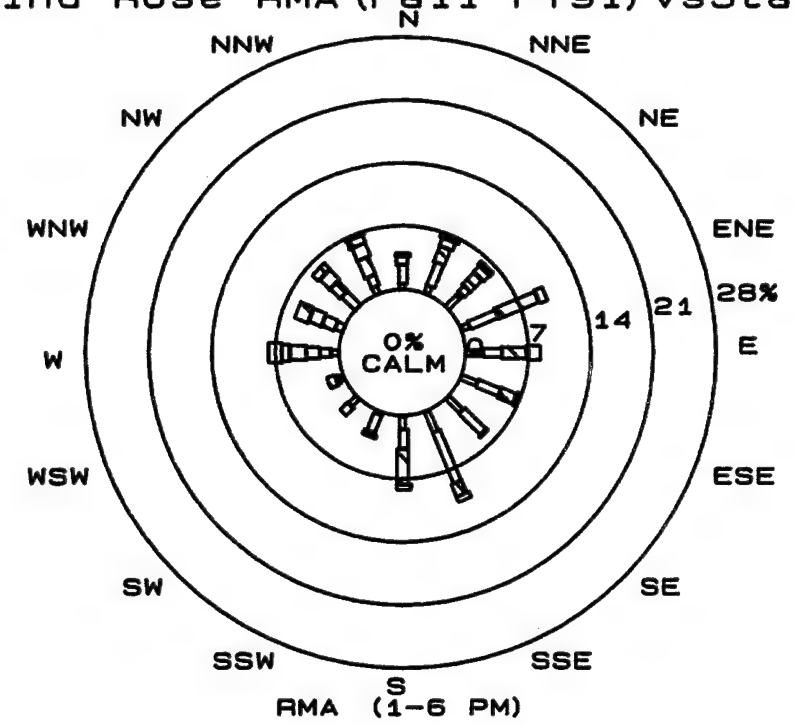
Stapleton (1-6 AM)



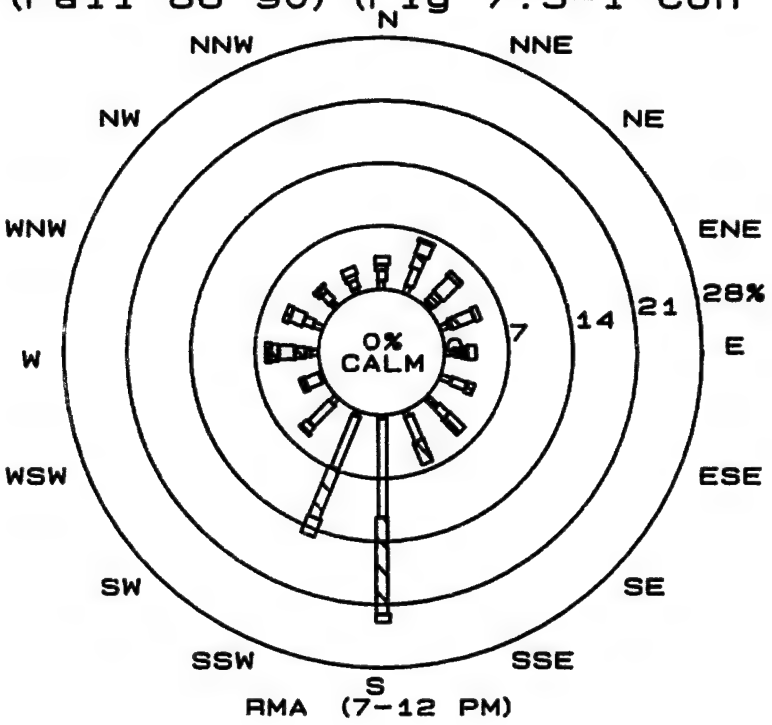


Stapleton (7-12 AM)

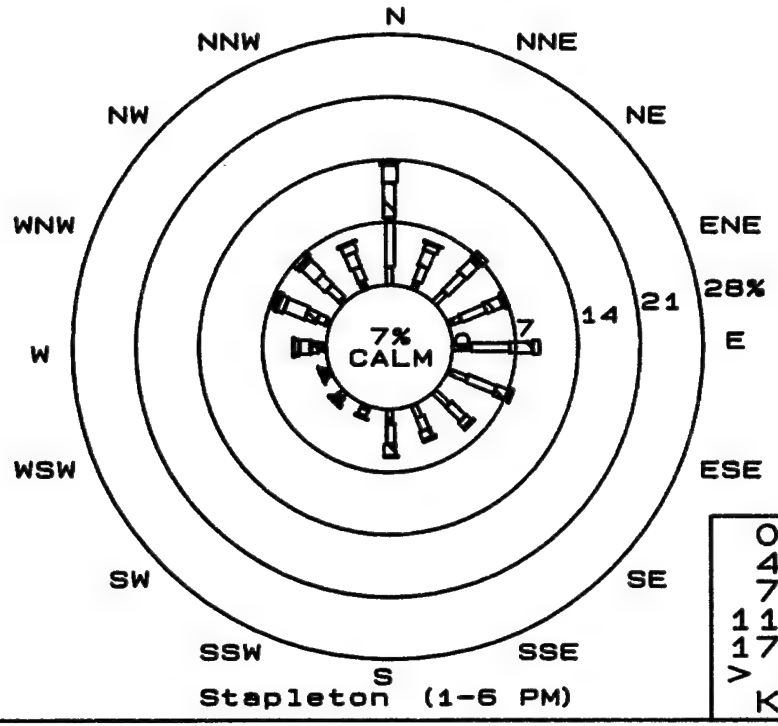
Wind Rose-RMA (Fall FY91) vsStapleton (Fall 86-90) (Fig 7.3-1 Con't)



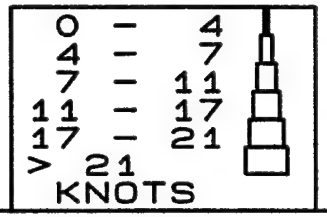
RMA (1-6 PM)

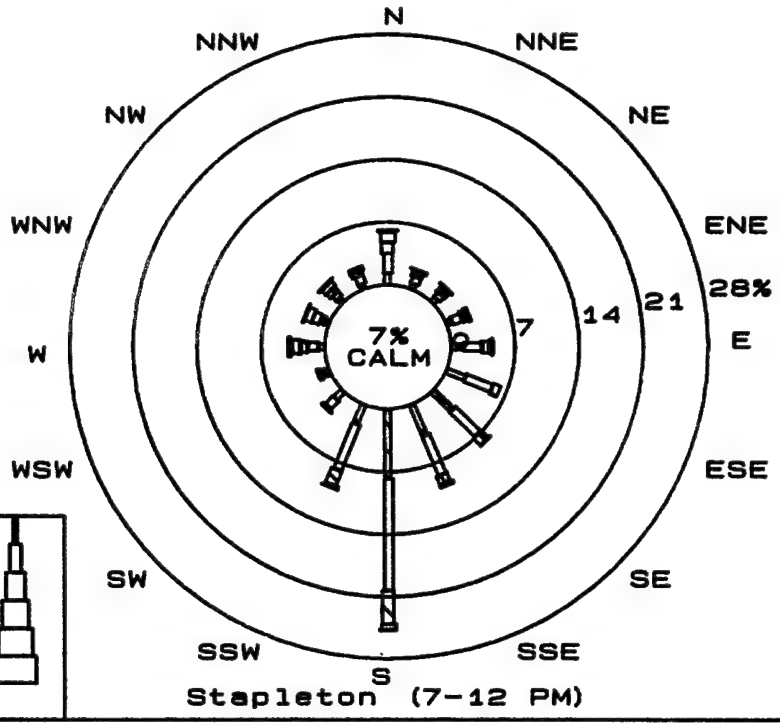


RMA (7-12 PM)



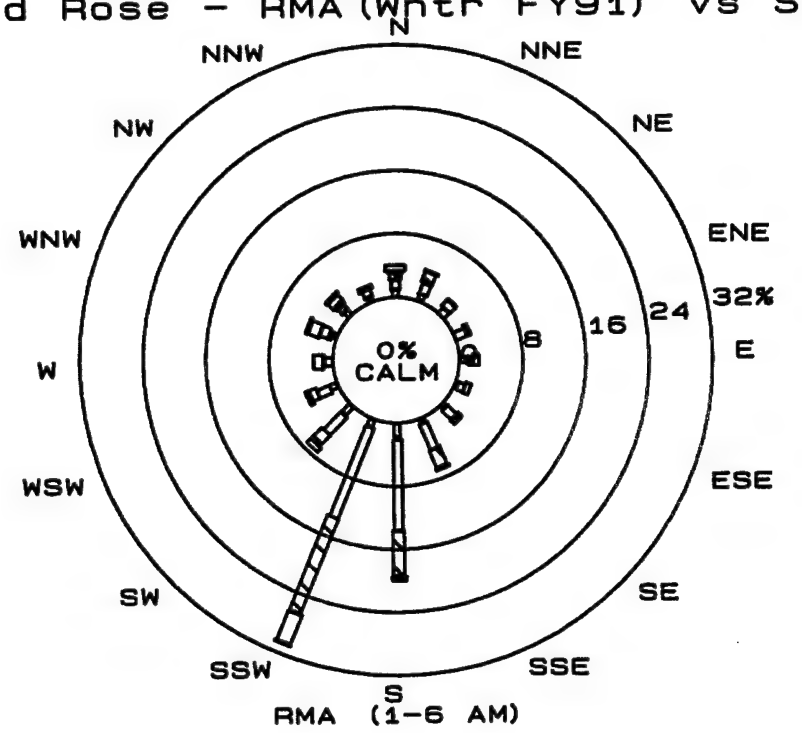
Stapleton (1-6 PM)



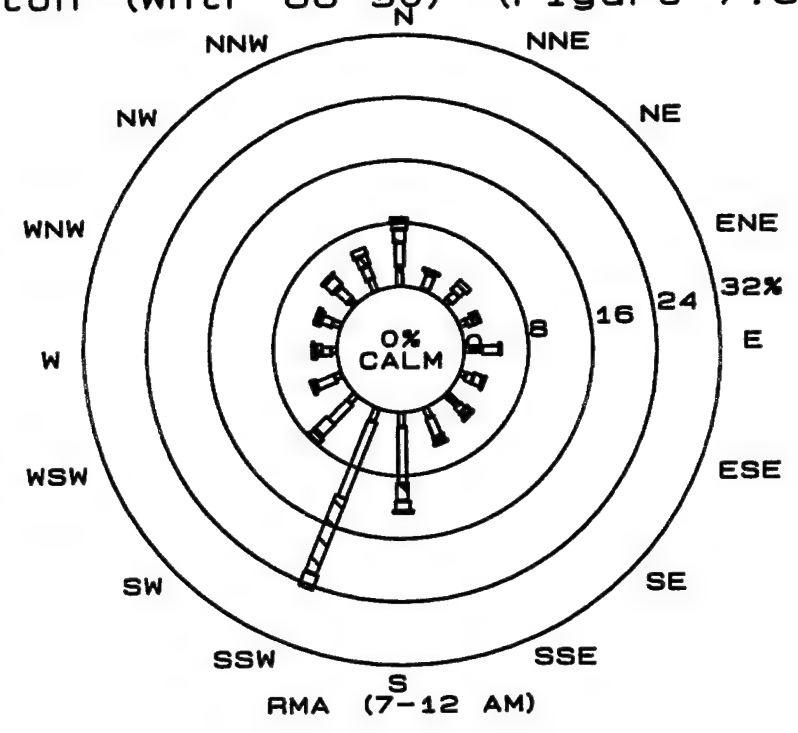


Stapleton (7-12 PM)

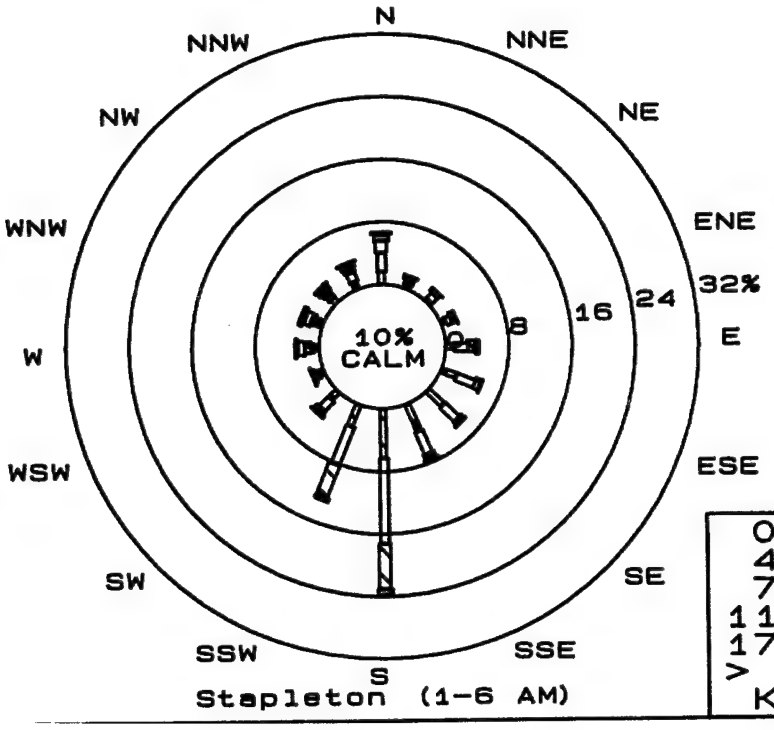
Wind Rose - RMA (Wntr FY91) vs Stapleton (Wntr 86-90) (Figure 7.3-2)



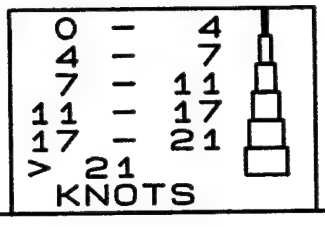
RMA (1-6 AM)

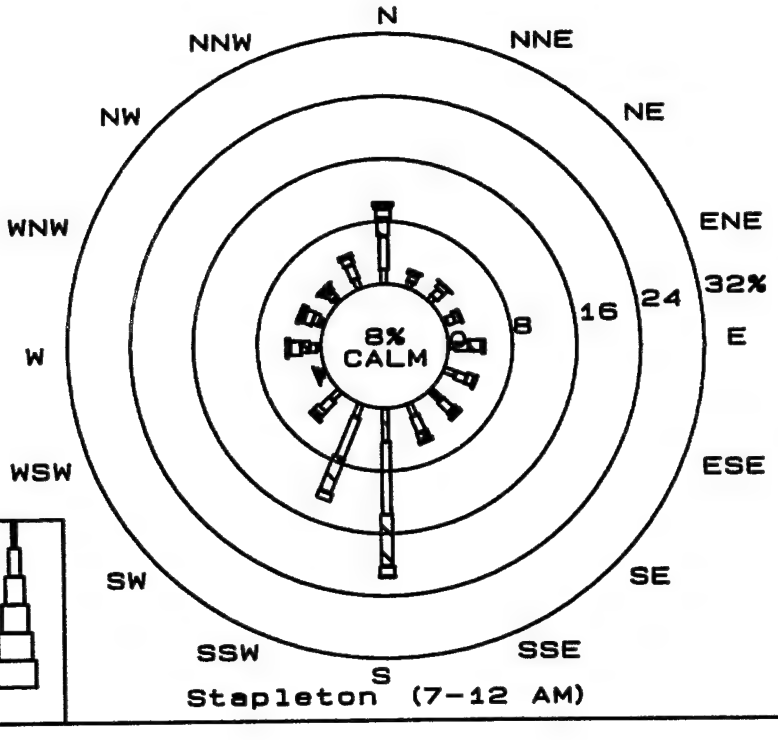


RMA (7-12 AM)



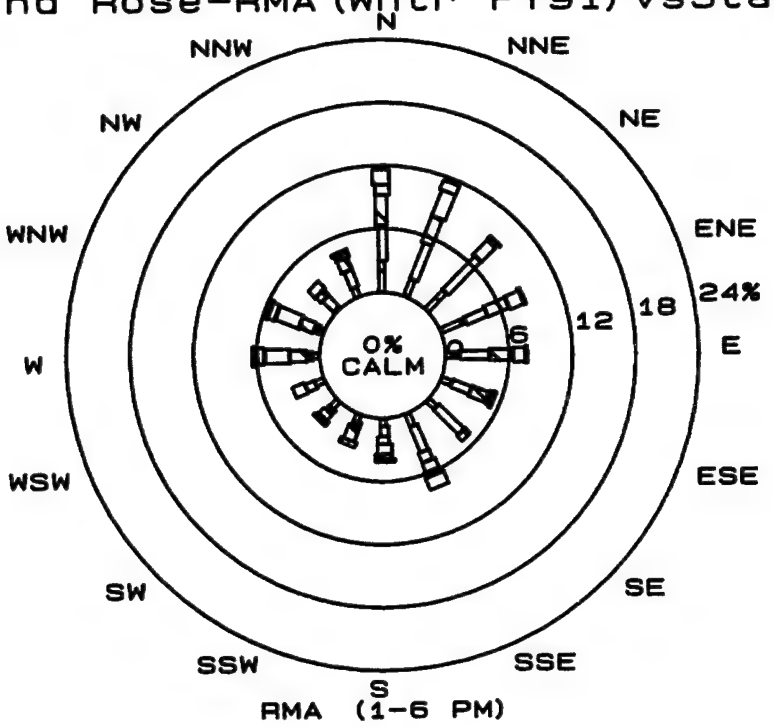
Stapleton (1-6 AM)



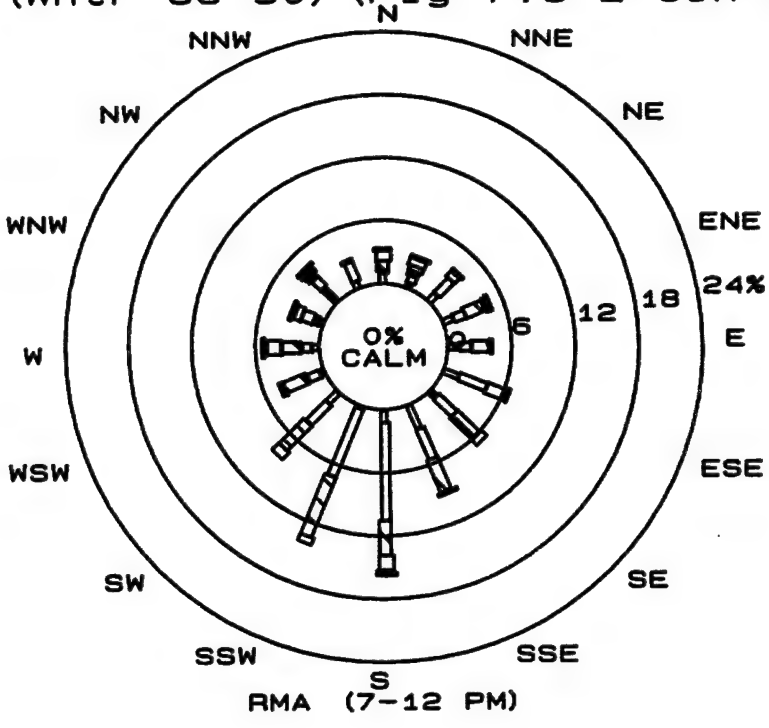


Stapleton (7-12 AM)

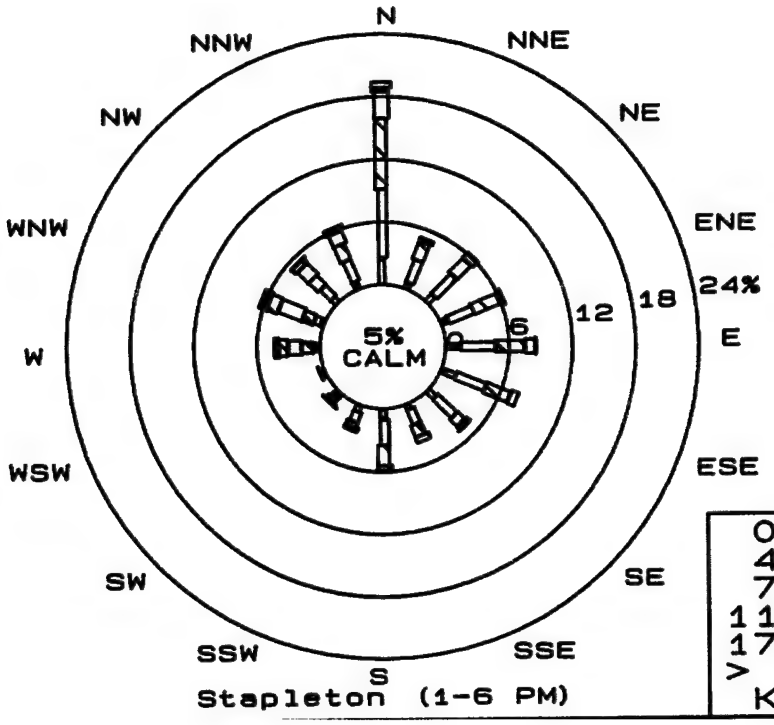
Wind Rose-RMA (Wntr FY91) vsStapleton (Wntr 86-90) (Fig 7.3-2 Con't)



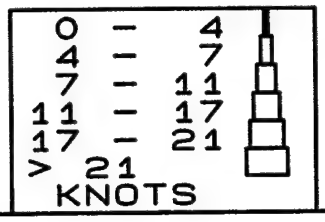
RMA (1-6 PM)

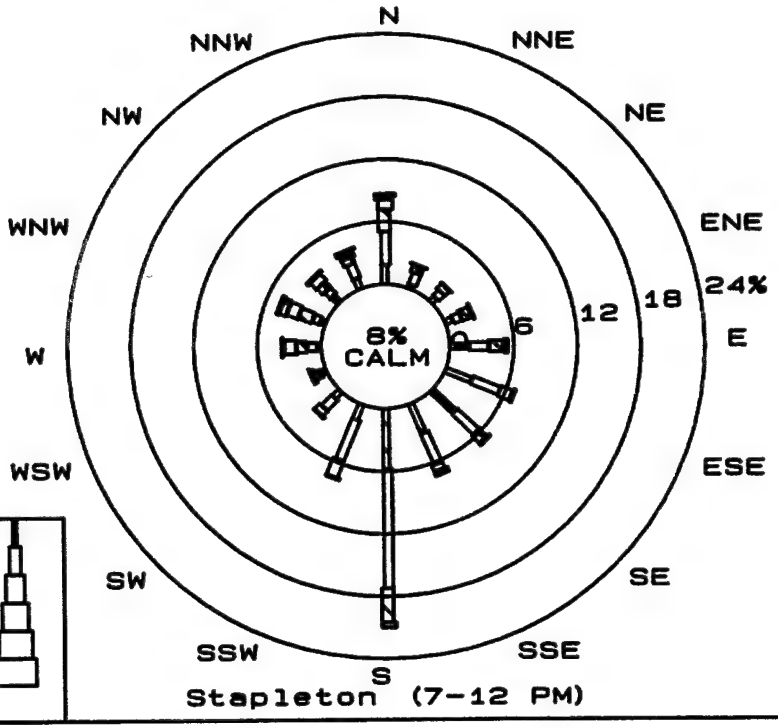


RMA (7-12 PM)

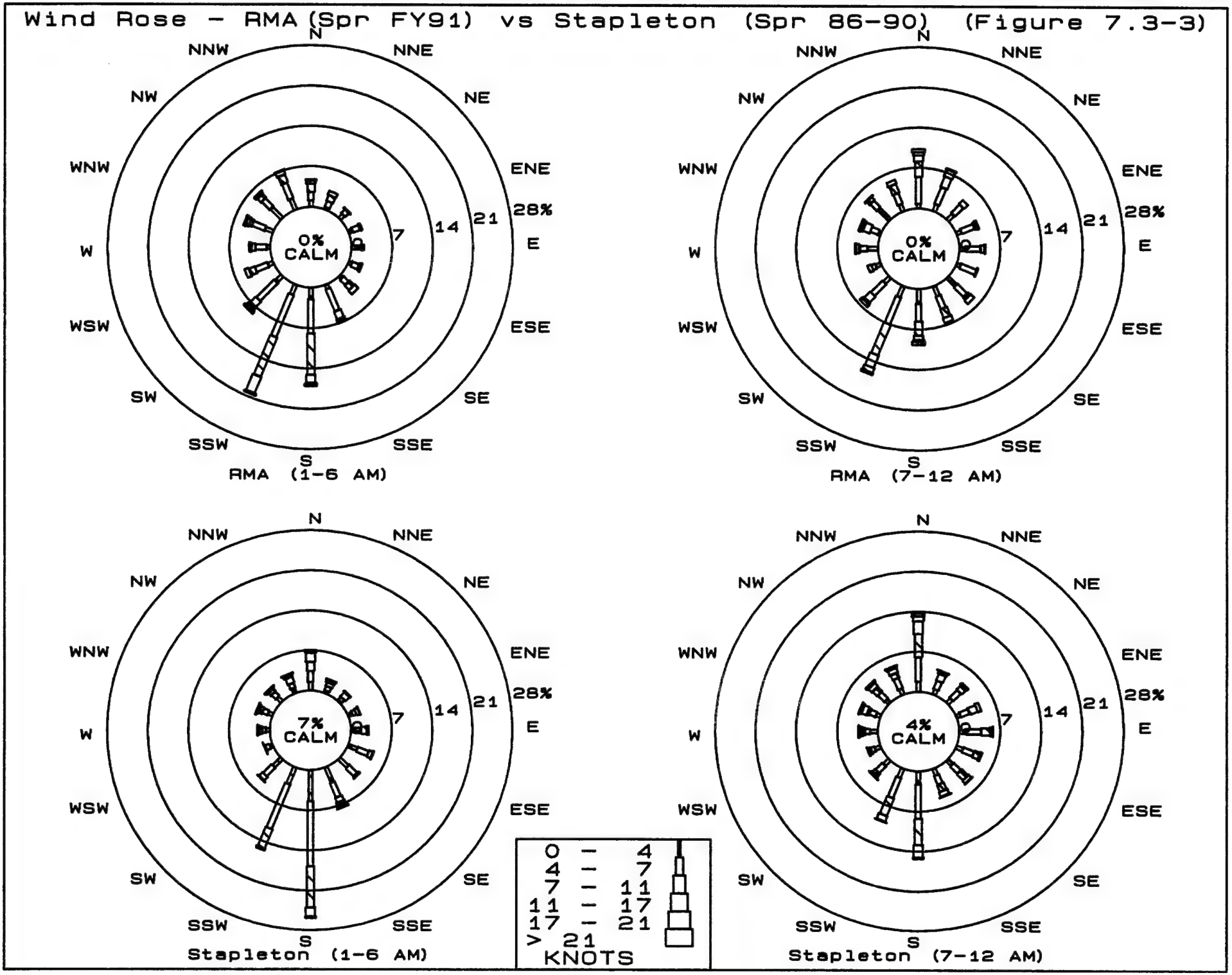


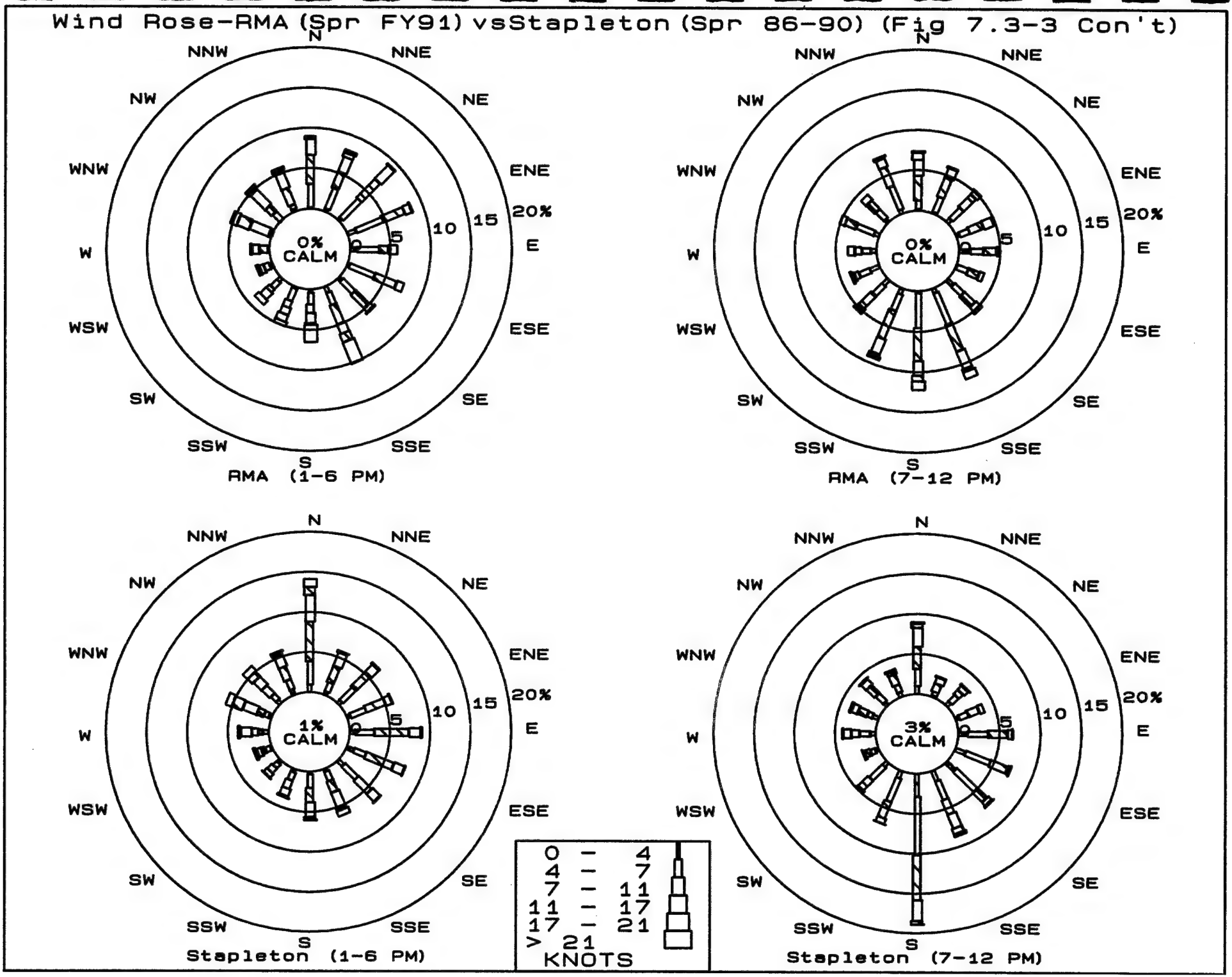
Stapleton (1-6 PM)

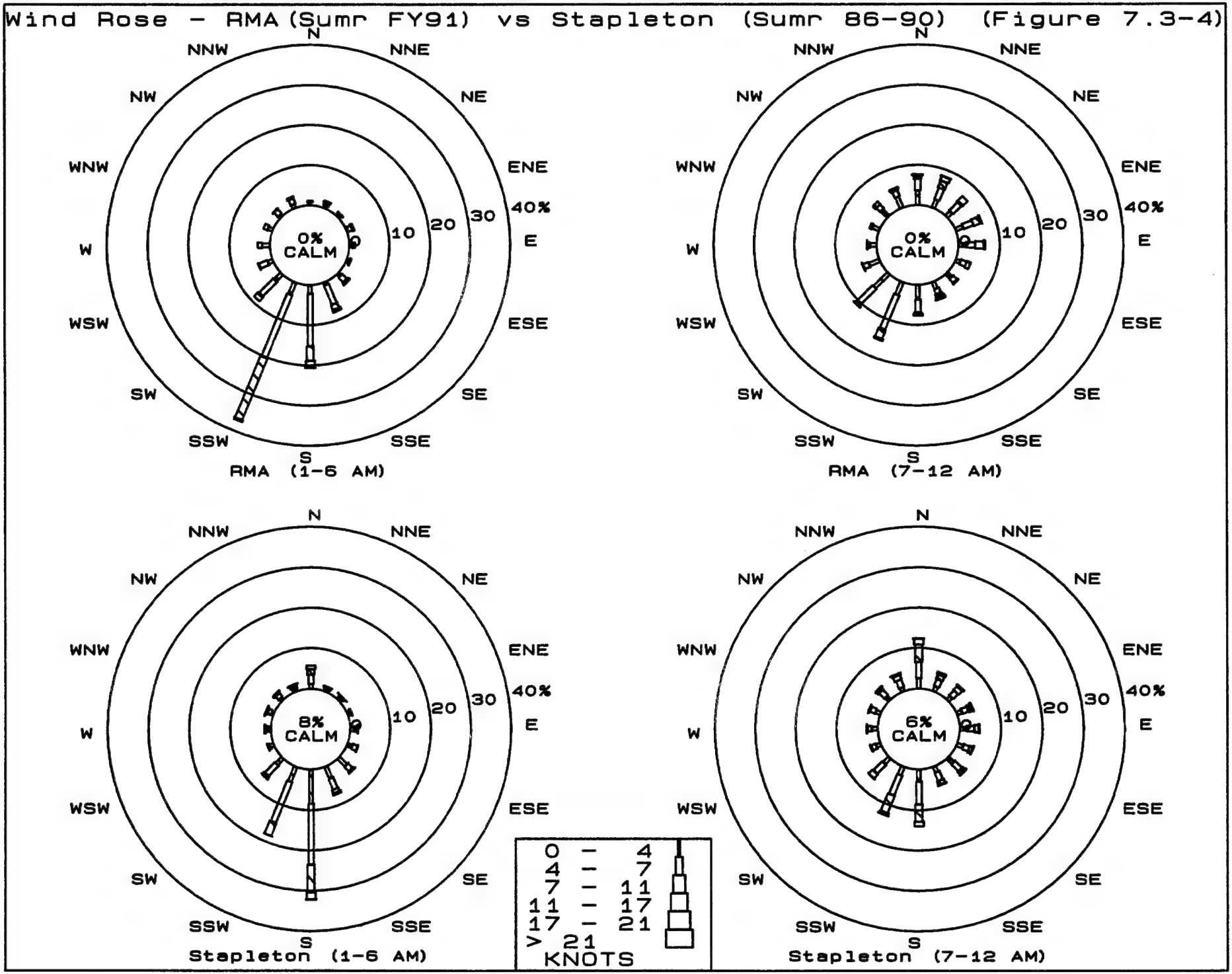


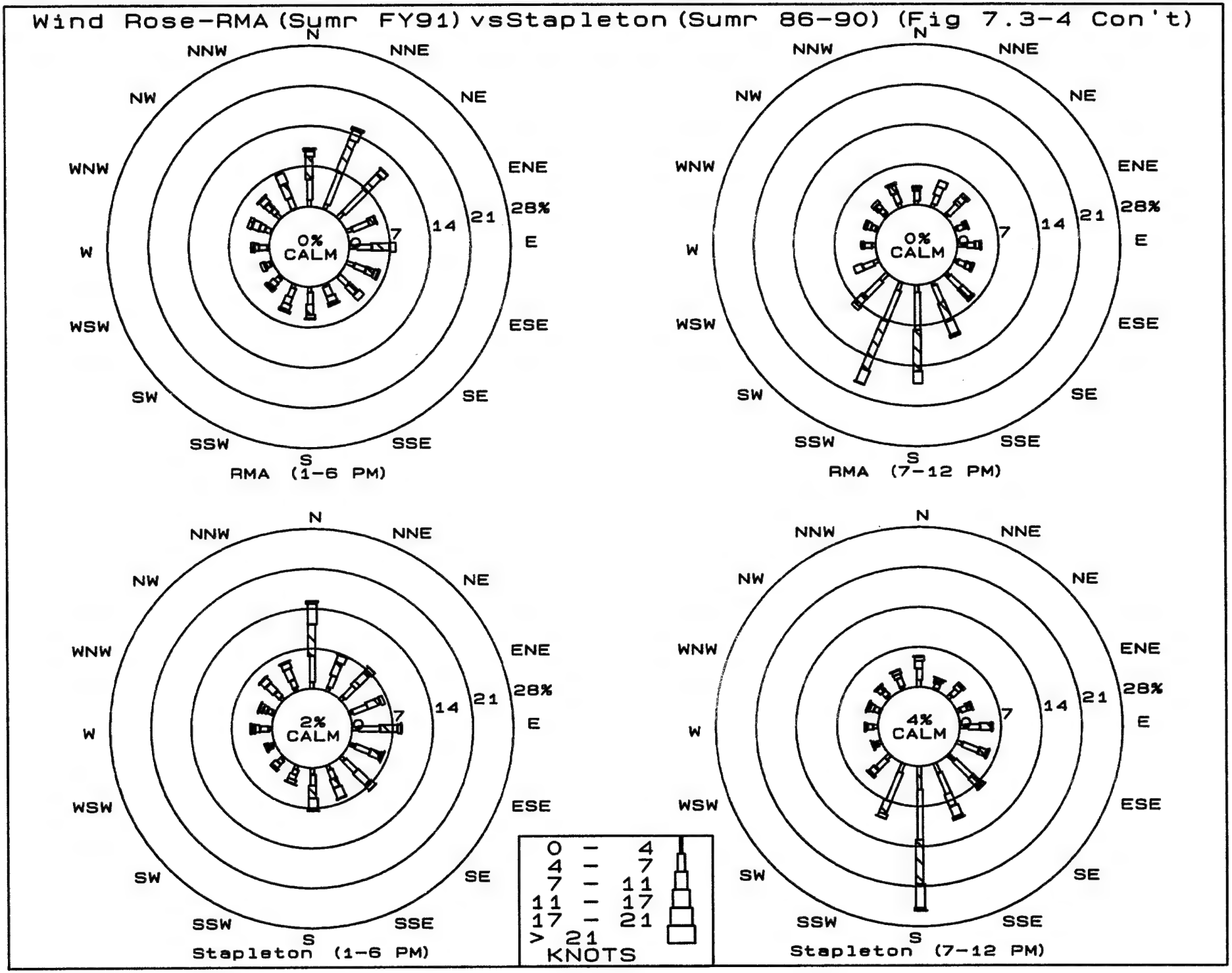


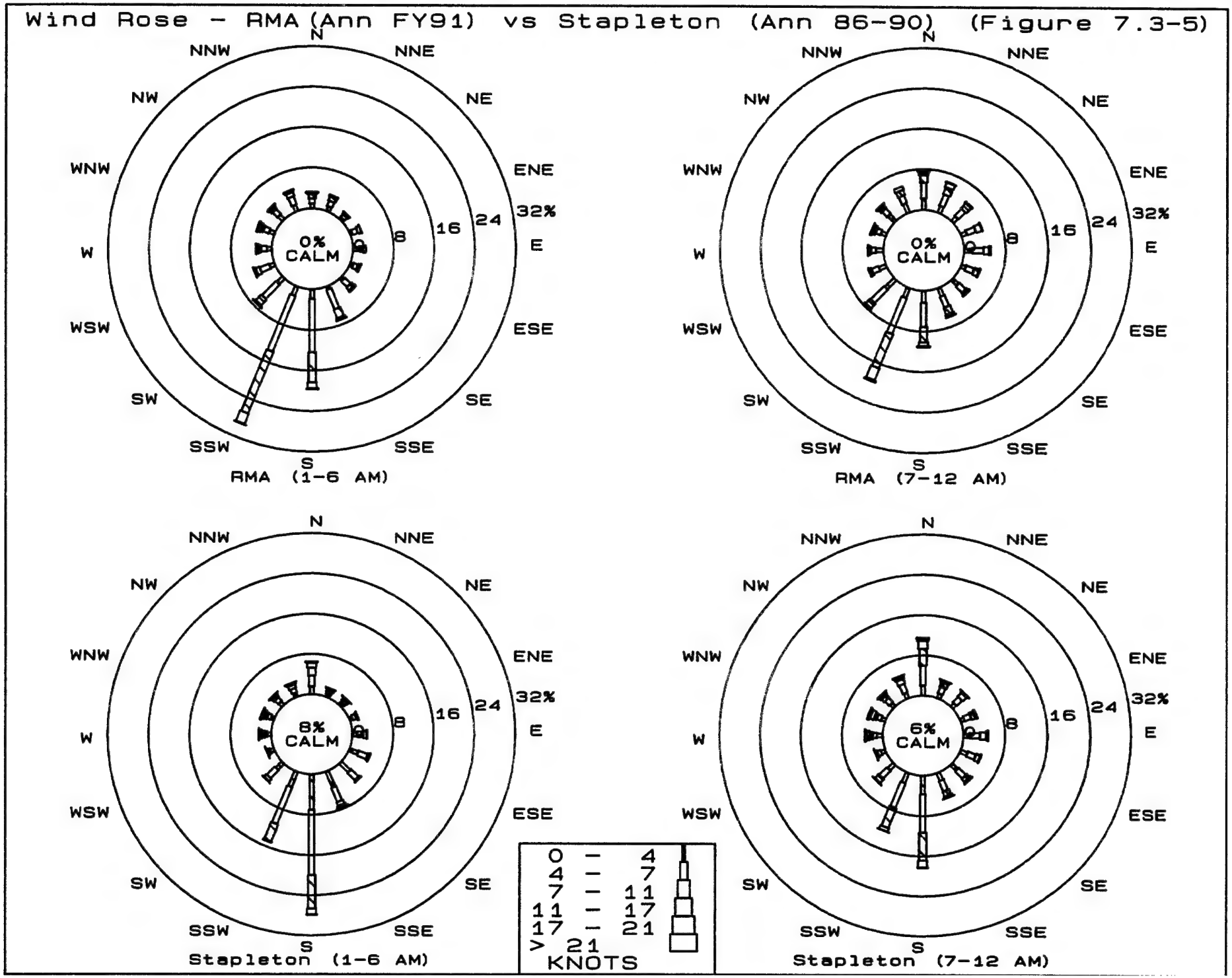
Stapleton (7-12 PM)


Wind Rose - RMA (Spr FY91) vs Stapleton (Spr 86-90) (Figure 7.3-3)
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
7
14
21
28%
0%
CALM
RMA (1-6 AM)
RMA (7-12 AM)
7%
CALM
Stapleton (1-6 AM)
4%
CALM
Stapleton (7-12 AM)
0 - 4
4 - 7
7 - 11
11 - 17
17 - 21
> 21
KNOTS

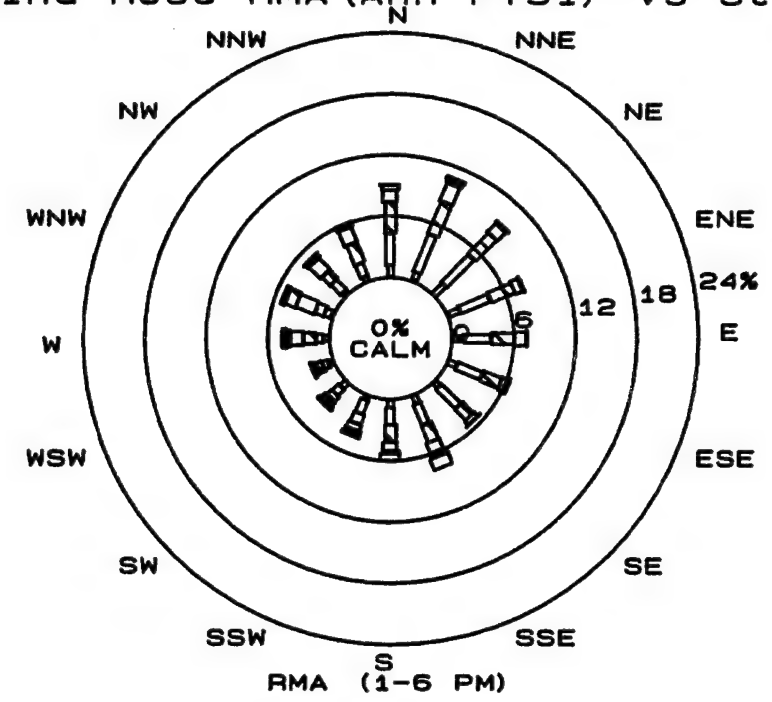

Wind Rose-RMA (Spr FY91) vsStapleton (Spr 86-90) (Fig 7.3-3 Con't)
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
0%
CALM
5
10
15
20%
RMA (1-6 PM)
RMA (7-12 PM)
1%
3%
Stapleton (1-6 PM)
Stapleton (7-12 PM)
0 - 4
4 - 7
7 - 11
11 - 17
17 - 21
> 21
KNOTS


Wind Rose - RMA (Sumr FY91) vs Stapleton (Sumr 86-90) (Figure 7.3-4)
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
10
20
30
40%
0%
CALM
RMA (1-6 AM)
RMA (7-12 AM)
8%
CALM
Stapleton (1-6 AM)
6%
CALM
Stapleton (7-12 AM)
0 - 4
4 - 7
7 - 11
11 - 17
17 - 21
> 21
KNOTS

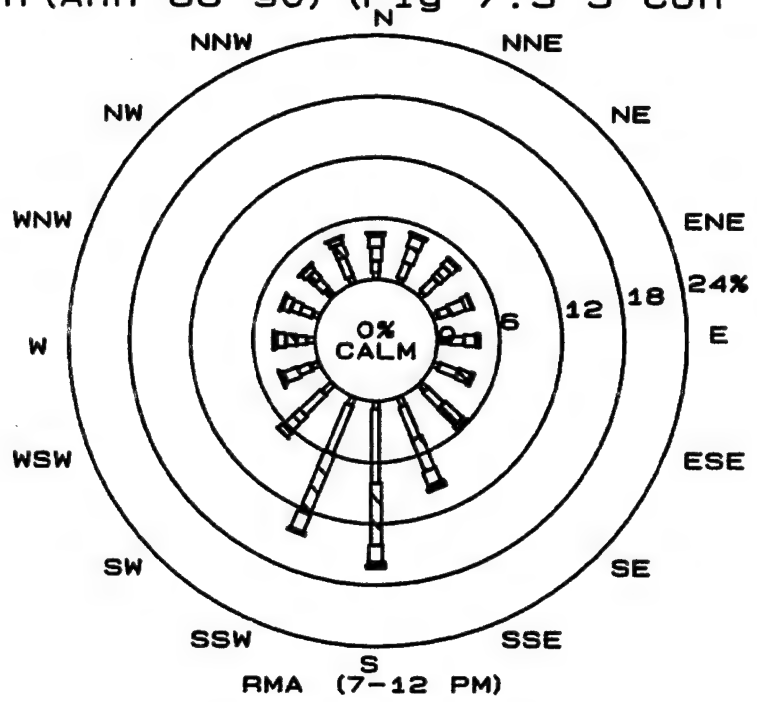

Wind Rose-RMA (Sumr FY91) vsStapleton (Sumr 86-90) (Fig 7.3-4 Con't)
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
0%
CALM
7
14
21
28%
RMA (1-6 PM)
RMA (7-12 PM)
2%
CALM
Stapleton (1-6 PM)
4%
CALM
Stapleton (7-12 PM)
0 - 4
4 - 7
7 - 11
11 - 17
17 - 21
> 21
KNOTS


Wind Rose - RMA (Ann FY91) vs Stapleton (Ann 86-90) (Figure 7.3-5)
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
8
16
24
32%
0%
CALM
RMA (1-6 AM)
RMA (7-12 AM)
8%
CALM
Stapleton (1-6 AM)
6%
CALM
Stapleton (7-12 AM)
0 - 4
4 - 7
7 - 11
11 - 17
17 - 21
> 21
KNOTS

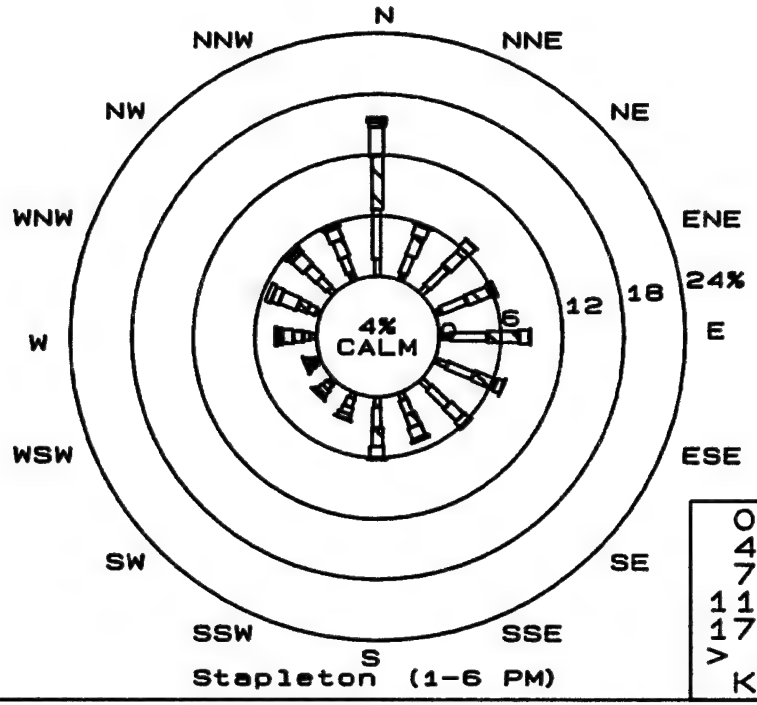
Wind Rose RMA (Ann FY91) vs Stapleton (Ann 86-90) (Fig 7.3-5 Con't)



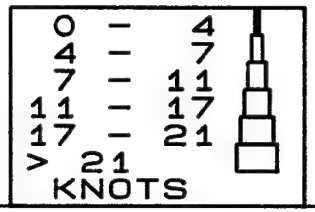
RMA (1-6 PM)

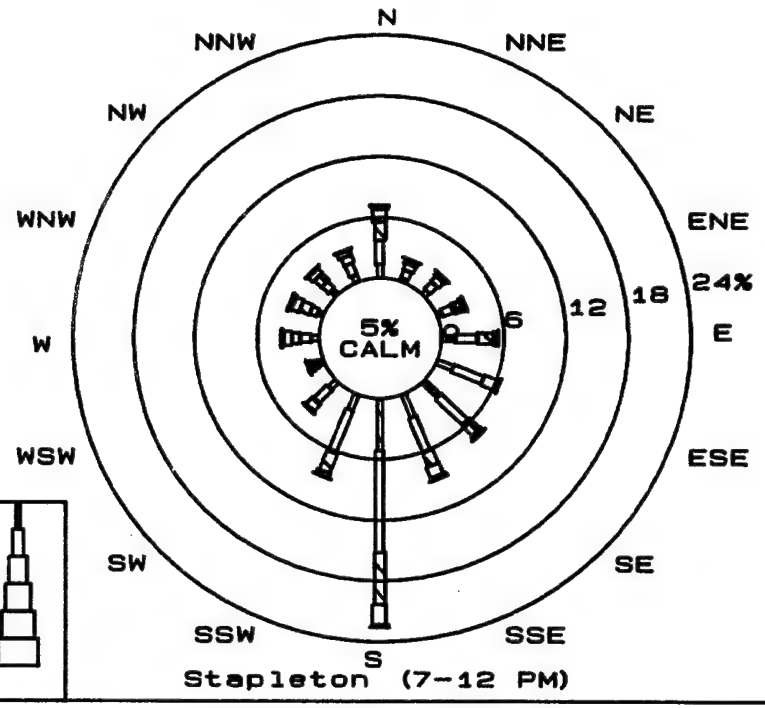


RMA (7-12 PM)



Stapleton (1-6 PM)





Stapleton (7-12 PM)

8.1 OVERVIEW AND GENERAL GUIDANCE

The CMP Quality Assurance (QA) Program for Air Monitoring was designed to assure that the data generated met the requirements of the project and needs of the data user. The QA also assures that the accuracy and precision of collected data are measurable and acceptable. The majority of monitoring and analytical techniques used were certified by PMRMA. Non-certified methods had USEPA approval. Each method has its own prescribed quality control and quality assurance procedures which is in accordance with the Chemical Quality Assurance Plan (PMRMA 1989). The guidelines for developing monitoring methods and procedures are described in the following documents:

- "CMP Field Procedures Manual"
- "PMRMA Certified Analytical Methods"
- "Ambient Monitoring Guidelines for Prevention of Significant Deterioration," EPA-450/4-87-007
- "Ambient Air Quality Monitoring, Data Reporting, and Surveillance Provisions," 40 Code of Federal Regulations, Parts 51, 52, 53 and 58
- "Quality Assurance Handbook for Air Pollution Measurement Systems," Volumes I, II and IV, EPA-600/9-76-005, EPA-600/4-77-027a, and EPA-600/4-82-060
- "Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air," EPA-600/4-84-041 and updates
- "Chemical Quality Assurance Plan," Version 1.0, July, 1989

The following discussion on the definition of quality assurance is taken from the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume I.

Quality assurance and quality control have been defined and interpreted in many ways. The more authoritative usages differentiate between the terms by stating that quality control is the "system of activities to provide a quality product," while quality assurance or quality assessment is the "system of activities to provide assurance that the quality control system is adequate and effective." In other words, quality assurance is the verification of quality control.

Under PMRMA definitions, quality assurance is the total integrated program for assuring and documenting the reliability of monitoring and measurement data and for integrating quality planning, quality assessment and quality improvement efforts to meet user requirements. Integrated into the QA plan is quality control (QC) which is the routine application of procedures for obtaining prescribed performance standards in the monitoring and measurement process. Examples of QC activities are field and trip blanks, laboratory spikes and duplicates.

For the purpose of the CMP Air Monitoring Program, quality control using project guidelines were those procedures that were routinely followed during the normal operation of the monitoring system. These included periodic field "spikes" and field blank sample analysis, collocated sample analysis, calibration of field and laboratory equipment, preventive maintenance, site inspections, and routine data screening and validation checks. Quality assurance (or quality assessment) were those procedures performed on a routine but less frequent basis to validate the data generation process. These assurance procedures were performed by a person not involved with the routine project activities. Quality assurance procedures included system and performance audits, standard intercomparisons, cross-checking of reported data values against original raw data records and data from other similar locations, and periodic evaluation of internal quality control data. The objective of the quality control and quality assurance procedures was to produce data that met RMA requirements measured in terms of precision, accuracy, representativeness, comparability, and completeness.

The remainder of this section is divided into the following subsections: a brief overview of the laboratory quality assurance and quality control program, a description of the field quality control results, a description of the field quality assurance results, and a description of quality assurance associated with data processing. More detailed discussions are provided in the CMP Field Procedures Manual (RLSA, 1988).

8.2 LABORATORY QC AND QA PROGRAM OVERVIEW

The laboratory quality assurance and quality control program was rigorous and was based on PMRMA certification procedures. These procedures assured the accuracy and integrity of the collected database through a control chart process. The certification program consisted first of rigorous pre-certification and certification procedures of the analytical methodologies that were satisfactorily completed before sampling and data collection. Second, prescribed routine quality control and quality assurance procedures were followed during the sampling program to assure that the entire sampling method was performing comparable to the level demonstrated during certification.

The laboratory certification procedures consisted of determining several key parameters. Extraction or desorption efficiencies were determined by spiking the sample media with known amounts of the target analytes and performing the analyses in accordance with the analytical guidelines. A percent recovery for each of the compounds was determined from multiple spiking tests. Accuracy adjustments were determined from the mean of the percent recoveries at certification. A 95 percent confidence level for the spike recovery data was calculated and used to validate the collected data. A range of concentrations was used to test the linearity of the laboratory instrument response and to certify an analytical range for each target analyte, with values denoted as the upper and lower certified reporting limits. Reporting ranges were determined at the time of certification. Values found below this range were reported as "less than" (LT) the lower reporting limit. Values found above this range were reported as "greater than" (GT), and were then estimated. These values are considered qualitative and are used as a "best guess" of concentration ranges. Upper limits did not apply to TSP and PM-10 measurements. For OCPs and metals analysis, extract solutions were diluted (if possible) for reanalysis if the initial readings were above the certified range and holding times for the extracts had not expired.

The VOC laboratory analysis technique differed significantly from other techniques because there was no possibility of diluting or reanalyzing samples. The VOC Tenax sorption tube was placed into a heating block connected to the inlet of the analytical instrument. This block or thermal desorber was quickly heated to desorb all the volatile compounds off the Tenax. A small air flow was passed through the tube simultaneously, allowing these compounds to be quickly injected into the analytical instrument through a heated stainless-steel interface. Since no sample remains after the injection process, there is no possibility of reanalysis. In the FY91 program, there were instances where a sample had collected an amount above the certified range for some compounds. An assessment of the concentration was made by using the hypothesized concentration curve above the certified range. The results in these cases produced the best estimate of the observed concentrations; however, these data were not certified in accordance with PMRMA standards and were likely to represent low estimates of actual concentrations. Although such GT values are not certified, they provide essential information on the magnitude of the detected compound. The GT value supplied by the laboratory produces a partial representation of what was collected on the sample tube. Since the volatile method allows only one analysis per tube, the estimated greater than values are utilized. Actual GT values are not present in the Installation Restoration Data Management System (IRDMS) database for comparison by other project managers, but are available in raw data packages. For the FY91 program, GT values from ESE Denver Laboratory were obtained from microfilmed data packets maintained by RMA.

In addition to the analyte measurements, laboratory accuracies, certified ranges, and extraction efficiencies were directly incorporated into the database processing system (IRDMS). In IRDMS the raw laboratory results are sent to Woodward-Clyde Consultants (WCC), and the data are checked for errors, adjusted for sample volumes and sent to DP Associates where they are kept in a QC holding database. Once the Army has accepted the data as having met the QA criteria, they are loaded into the official database. Data outside of certified ranges and rejected under QA criteria are placed in a rejection data file for informational purposes only. The resulting product is a high quality analytical database.

8.3 FIELD QUALITY CONTROL PROGRAM

8.3.1 Organization

The field monitoring team was organized to conduct several activities that provided data quality control for the program. At the outset, a monitoring team supervisor was designated and a set of procedures was drawn up to address quality control.

Standard field data sheets were used by the project team. Each team member was trained in the use and entry of data on this form. Forms were documented in project files, and copies were distributed to the project manager for periodic review. Calibration data sheets were also drawn up for the project and the calibration team was trained in their use. The field and calibration data sheets were stored on site and a copy was sent to the project manager. The field supervisor was responsible for assuring that these records were maintained, routinely reviewed, and updated. Final deposition of these documents are the project files and will ultimately be sent to PMRMA at project close-out.

8.3.2 Field Program Quality Control

For each of the sampling techniques used, the air quality technical plan specifies target flow rates and sampling durations. These values were used during the field sampling activities and were documented by periodic equipment calibrations as well as checks during each sampling event. Quality assurance limits were set up using the EPA Quality Assurance Handbooks for acceptable instrument performance. When a flow rate or elapsed timer was outside of acceptable limits, corrective maintenance was performed to bring the defective component or activity back into tolerance. The activities were documented and kept with field file records.

The high-volume field equipment used to sample TSP, PM-10, and metals were electronically flow controlled to maintain a constant flow rate. A certified flow measuring orifice was routinely used to calibrate the flow rate set point. Calibrations were performed once per quarter, or more frequently if needed. For the OCP high-volume samplers, a flow rate gauge was used to monitor the flow rate of the

sampler. During calibration of these samplers, a range of flow rates was measured with the orifice, and a linear regression was developed relating the sample indicator reading to the orifice flow rate. The maximum deviation of any flow rate point from the linearly interpolated value should be less than 7 percent for the TSP, PM-10, and OCP samplers. For TSP and PM-10, visual inspection of the flow chart indicated whether the flow deviated during the sampling period.

The low-volume field sampling equipment, which was used for sampling VOCs and mercury, included VOTAs as well as Micromax and Gilian constant flow sampling pumps equipped with rotometers. VOTAs were calibrated quarterly. During calibration the VOTA rotameter settings needed to achieve a desired flow rate were determined using a certified mass flow meter. Before each field sampling event, the pumps were calibrated and set to specific flow rates as determined by a certified mass flow meter. During a sampling event, personnel routinely inspected the rotameter to ensure correct flow rate readings.

8.3.3 Quality Control Field Sample Results

8.3.3.1 VOC Quality Control Results

The sampling media for the collection of VOCs consisted of a front sorbent tube containing Tenax and a second, or backup tube containing Tenax and charcoal. Ideally, the front tube will collect all of the VOCs. The backup tube is to collect the compounds only if the front tube cannot retain all of them. During sample collection, if the volume of air drawn through the tube exceeds the breakthrough volume, the Tenax tube in the sampling train may be unable to collect and retain the total amount of one or more of the compounds present.

In an effort to increase confidence in ambient air monitoring data, the standard VOC method prescribes the use of collocated samples as a quality assurance procedure. The recommended performance criteria specifies that the difference in concentration between each of the pair of collocated samples should be within 25 percent of the sample pair. This technique has been used by the CMP and results are discussed in Section 8.4, and indicate generally acceptable precision existed for the VOCs.

As an additional quality control measure, field blank values were compared to field analytical values. As stated in the VOC method, a blank sorbent trap should contain less than 10 ng of each target compound before it is sent to the field. Table 8.3-1 presents a summary of the target VOC blank values for FY91. For most of the target compounds, field blank levels were less than the certified reporting limit (which generally corresponds to approximately 10 ng per sample). However, some field blanks showed detectable levels of benzene, ethyl benzene, toluene, trichloroethane, 1,1,1-trichloroethane, tetrachloroethane, and total xylene.

8.3.3.2 Semi-Volatile Organics and PUF Quality Control Results

Quality control samples for organochlorine pesticides consisted of field blanks, collocated samples, and aerated field spikes. The OCP sampling methods employed a high-volume sampler to draw air through a module containing a quartz filter and a polyurethane foam sorbent plug. In the analytical method, a gas chromatograph/electron capture detector (GC/ECD) was used for detection. This device analyzed only the organochlorine pesticides for which it was certified and had a very low detection limit. The reported concentrations for one of these compounds, aldrin, must be used with caution. This is due to the potential for stripping or oxidation of aldrin during field sampling and to the known low recovery of spiked aldrin samples.

In an effort to quantify the recovery of the OCP sampling and analytical method, two field spiking events were performed for CMP's FY1991 air monitoring program. The event conducted on 6/18/91 consisted of two spiked samples taken concurrently with one control (unspiked) sample. The second event took place on 6/20/91 and included one spiked sample and one control sample. The solution spiked with all target compounds was prepared by the ESE/Denver laboratory and sent to the field team. The concentration of each compound in the solution was 1 μg/ml. Samples were spiked by applying the solution directly onto a filter fiber at the beginning of the sample period. The felt filter was placed over the regular quartz filter at the beginning of the sample period. One ml was applied to each spiked sample taken during the first event and 0.75 ml was applied to the spiked sample during the second event.

The results of the spiking events are listed in Table 8.3.2. Note that no aldrin or isodrin was recovered, but that with the exception of chlordane, all of the other compounds showed high recoveries. Analytical results for aldrin and isodrin must be interpreted carefully in view of their zero recoveries. The low recoveries displayed by chlordane during the first event may be explained by the high background concentrations that was measured on that day. The results for the other analytes showed that the methods employed are quite efficient at collecting and retaining the contaminants of concern.

Table 8.3-3 presents a summary of the target OCP blank values for FY91. All field blank values were less than the certified reporting limit.

The collocated OCP samples showed that good precision exists within the method. The precision analysis for OCPs will be discussed in greater detail in Section 8.4.

8.3.3.3 Quality Control Results - Metals

Collocated samples and field blanks comprised the quality control samples for metals. Table 8.3-4 presents a summary of the target metal blank values for FY91. Nearly all values were less than the certified reporting limit. The collocated results showed that the method provides stable results, but care must be taken in some metals data interpretation. This will be discussed further in Section 8.4.

8.3.3.4 Quality Control Results - TSP and PM_{10}

Collocated samples and field blanks comprised the quality control samples for TSP and PM_{10}. Table 8.3-5 presents a summary of field blank values for TSP and PM_{10} filters. Net weights indicate an average bias of less than 1 $\mu g/m^3$ over a 24-hour period. Results of collocated samples are discussed in Section 8.4.

8.3.4 Data Processing

A series of formal steps was implemented to ensure the quality of data generated under this program. The laboratory reported total micrograms per sample media for each sample; the IRDMS corrected this weight based on method accuracy determined during

method certification and corrected for each analyte as required. The monitoring team calculated the total volume associated with each sample; and the adjusted weight was divided by the sample volume to obtain a unit mass concentration per unit volume of air sampled.

The quality assurance group reviewed the laboratory quality control data, including surrogate and spike recoveries and general compliance with the PMRMA quality control methodology. The acceptability of each lot was addressed by the laboratory and was reviewed for approval by the quality assurance team. The control charts were reviewed to indicate method control and submitted to PMRMA. The laboratory provided a hard copy and a diskette of uncorrected sample weights to the data management group. The printout of diskette data was compared with the hard copy results and any discrepancies were resolved.

The field team generated a sample volume computation on spreadsheet software using the field calibration, flow check and sample time duration data. Spreadsheet entries were checked and volume computations were verified by the quality assurance group. The data processing group generated sample concentrations from the weight and volume data. Group and record check which are two subroutines in the IRDMS software were performed for all lots of data submitted to W-C. These routine electronically verified holding times, analysis times and method certification criteria. Finally, the quality assurance program provided documentation that the database was generated in accordance with quality assurance procedures.

8.4 ASSESSMENT OF DATA PRECISION AND COLLOCATED DUPLICATE SAMPLING RESULTS

The CMP collocated sampling effort was performed at Site AQ5 for TSP, PM-10, and metals. Site FC1 was the collocated site for VOC and OCP samples. The pairs of samplers were located approximately 3 meters from one another for all sample types except VOCs. The VOC collocated samples were taken side by side within a few inches of each other. Results were calculated for all target compounds and detailed data are presented in Appendix G. Collocated sample comparisons are listed in Table 8.4-1. Only sample pairs with results above the lower certified reporting limit (LCRL) were used in this summary.

There were 35 pairs of collocated samples used in the TSP precision analysis. The percent difference ranged from -40% to + 17%. Nine of the 35 pairs analyzed were outside of the EPA recommended tolerance of $\pm$ 15 percent for precision. Upper and lower confidence limits were calculated for the precision data: the limits are 9.6 to -29.4 percent.

Thirty-eight pairs of collocated PM_{10} samples were taken; there were 22 sample pairs with concentrations of less than 20 $\mu g/m^3$ which were not included in the precision calculations. Sixteen samples were used to calculate precision accuracy. The average difference was -0.74 percent and the standard deviation was 3.22 percent. The upper and lower confidence intervals were 4.92 to -6.39 percent.

The precision calculation worksheets for TSP and PM_{10} are in Appendix G.

A total of 18 pairs of collocated samples was collected and analyzed for metals. Copper was detected in all pairs of samples and zinc was found in all but two. There were several large percentage differences for copper and a few for zinc; the reason for these values may be that zinc and copper are known artifacts in the quartz filter material. Because of the known contamination, precision of this method for these analytes cannot be shown as representative values for the method. There were only two pairs of samples with detections of lead and only one of arsenic, all demonstrating acceptable precision. No detections of cadmium or chromium were found in any of the samples. Assessment

of precision for these metals cannot be made without more data. Overall, the results indicate that the method is providing generally stable, reliable results for metal data, but copper and zinc results should be used with a measure of caution.

There were 41 pairs of OCP samples collected and analyzed which provided validated usable data. There were only three samples with average percentage differences greater than ± 35 percent. Although no guidelines exist for comparing collocated OCP samples in air, a nominal ± 35 percent value is used due to the variability inherent in the sample matrix and adsorbent (± 35 percent is also used in comparing duplicates in soil for the CLP program. The three high values were 53.6 percent for aldrin, -36.2 percent for endrin and 55.2 percent for dieldrin. The three values appear to be outliers and the rest of the data demonstrate that good correlation existed. There was only one detect each for ppDDE and ppDDT and none for isodrin.

A total of 44 pairs of VOC samples were collected and analyzed. Although there were only six VOC analytes with mean percentage difference greater than ± 25, several individual pairs showed percentage differences greater than this mark. This may be due to the inclusion of a number of estimated concentrations which were above the certified reporting range. Percent differences for pairs that include estimated concentrations introduce more variability in to the method. Consequently, although the values within each collocated pair are comparable, particularly when both are within the certified reporting limits, these results show that there is more variability in the VOC method than the other methods.

The continuous monitoring stations analyzed for ozone, carbon monoxide, sulfur dioxide, and nitrogen oxides. Precision checks were performed on the individual analyzers at least two times per month. These checks entailed analyzing a calibration/standard gas of known concentration. The response of the analyzer was recorded as shown in Table 8.4-2 and in Appendix G. The percent difference was calculated indicating whether the instrumentation required corrective maintenance. Average percent differences were consistently 6 percent or less. Actual percent differences were also less than 12 percent. Stability of the analyzers is evident, giving reasonable confidence for results observed.

8.5 QUALITY ASSURANCE FIELD PROCEDURES

CMP air monitoring, quality assurance procedures included system quality assurance audits, performance audits of sampling equipment, and comparisons of calibration standards to other reference standards for FY91.

8.5.1 System Audits

System audits are the external inspection and review of monitoring operation and documentation. System quality assurance audits of the air sampling program for CMP were conducted by the project quality assurance coordinator. Operations that were audited included sample handling and use of sample containers or collectors, and documentation. Results were reported to project management with recommendations for long-term solutions and resolutions to immediate corrective actions. These reports are contained within the project files.

8.5.2 Performance Audits of Field Sampling Equipment

Performance audits were performed by personnel independent of the project. The audits consisted of testing the calibration of samplers with calibration standards other than those used to assess daily operation of the samplers.

Detailed results of the audits are listed in the CMP Quarterly Audit Reports. Summary tables for each audit report are provided in Appendix G. For each sampler, the operator-determined flow rate was compared to the audited flow rate and a percent difference was calculated. The results were compared to EPA guidelines of ± 7 percent for an acceptable audit result. Field personnel were informed of any discrepancy and performed the required corrective action for this audit. Corrective actions were taken immediately and entered in the daily logbook.

EPA guidelines were employed to summarize overall accuracy among the network of samplers. Calculation procedures are detailed in the Federal Register, Vol. 51, No. 53, March 19, 1986. The procedures call for calculating the average percent difference, standard deviation, and ± 95 percent confidence limits for all audit points for any

particular type of sampler in the monitoring network. Three types of samplers were examined, including TSP samplers, PM-10 samplers, and the OCP samplers. For each type of sampler, the number of audits performed was recorded along with the average percent difference and the ±95 percent confidence limits. These were compared to EPA recommended probability limits of ±20 percent for satisfactory accuracy. Results are listed in the CMP Quarterly Audit Reports, with summary tables in Appendix G.

An independent audit of the field and laboratory procedures was performed by Martin Marietta Energy Systems (MMES) in March 1991. MMES noted that the field team was achieving the objectives of the air program.

8.5.3 Calibration and Certification of Standards

The accuracy of flow calibration equipment was critically important for the type of monitoring performed in the CMP. Flow rate standards were calibrated against NIST traceable or other authoritative standards. Appropriate calibration intervals are yearly for the high-volume orifices and 3 to 6 months for the mass flow meter low-volume standards. The high-volume orifices and mass flow meter standards used in the CMP network were certified and compared to standards contained in the USEPA Region VIII Quality Assurance laboratory.

Table 8.3-1 CMP Target Volatile Organic Compounds (VOC) Blank Values (in ug)

Date	Site	Tag #	111TCE	112TCE	11DCLE	12DCE	12DCLE	4BFB	BCHPD	C6H6	CCL4	CHCL3
01/23/91	FC5FB	9	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.304	LT 0.012	LT 0.016	LT 0.018	LT 0.012
01/29/91	FC5FB	18	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.314	LT 0.012	LT 0.016	LT 0.018	LT 0.012
02/04/91	AQ5FB	27	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.491	LT 0.012	LT 0.016	LT 0.018	LT 0.012
02/10/91	AQ5FB	36	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.425	LT 0.012	LT 0.016	LT 0.018	LT 0.012
02/22/91	AQ5FB	53	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.175	LT 0.012	0.034	LT 0.018	LT 0.012
02/28/91	AQ5FB	62	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.137	LT 0.012	LT 0.016	LT 0.018	LT 0.012
03/06/91	AQ5FB	72	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.250	LT 0.012	LT 0.016	LT 0.018	LT 0.012
03/12/91	AQ3FB	82	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.226	LT 0.012	LT 0.016	LT 0.018	LT 0.012
03/18/91	FC1FB	92	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.102	LT 0.012	LT 0.016	LT 0.018	LT 0.012
03/24/91	FC2FB	101	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.205	LT 0.012	LT 0.016	LT 0.018	LT 0.012
03/30/91	FC2FB	112	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.199	LT 0.012	LT 0.016	LT 0.018	LT 0.012
04/05/91	FC5FB	122	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.412	LT 0.012	LT 0.016	LT 0.018	LT 0.012
04/11/91	QI1FB	132	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.194	LT 0.012	LT 0.016	LT 0.018	LT 0.012
04/17/91	AQ2FB	142	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.245	LT 0.012	LT 0.016	LT 0.018	LT 0.012
04/23/91	FC1FB	152	0.148	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.144	LT 0.012	0.026	LT 0.018	LT 0.012
04/29/91	AQ3FB	164	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.217	LT 0.012	LT 0.016	LT 0.018	LT 0.012
05/05/91	AQ2FB	175	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.169	LT 0.012	LT 0.016	LT 0.018	LT 0.012
05/11/91	FC5FB	195	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.146	LT 0.012	LT 0.016	LT 0.018	LT 0.012
05/17/91	AQ2FB	205	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.419	LT 0.012	LT 0.016	LT 0.018	LT 0.012
05/23/91	AQ3FB	218	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.265	LT 0.012	LT 0.016	LT 0.018	LT 0.012
06/04/91	FC2FB	238	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.130	LT 0.012	LT 0.016	LT 0.018	LT 0.012
06/10/91	FC1FB	248	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.196	LT 0.012	LT 0.016	LT 0.018	LT 0.012
06/12/91	FC1FB	258	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.165	LT 0.012	LT 0.016	LT 0.018	LT 0.012
06/16/91	FC1FB	270	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.216	LT 0.012	LT 0.016	LT 0.018	LT 0.012
06/20/91	COMBS	276	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.465	LT 0.012	LT 0.016	LT 0.018	LT 0.012
06/20/91	QI1FB	286	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.197	LT 0.012	LT 0.016	LT 0.018	LT 0.012
06/22/91	FC5FB	296	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.224	LT 0.012	LT 0.016	LT 0.018	LT 0.012
06/26/91	AQ10FB	306	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.193	LT 0.012	LT 0.016	LT 0.018	LT 0.012
06/28/91	FC1FB	316	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.221	LT 0.012	LT 0.016	LT 0.018	LT 0.012
07/04/91	QI1FB	326	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.292	LT 0.012	LT 0.016	LT 0.018	LT 0.012
07/10/91	QI2FB	338	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.227	LT 0.012	LT 0.016	LT 0.018	LT 0.012
07/16/91	AQ3FB	348	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.244	LT 0.012	LT 0.016	LT 0.018	LT 0.012
07/22/91	FC1FB	358	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	LT 0.090	LT 0.012	LT 0.016	LT 0.018	LT 0.012
07/29/91	QI2FB	10	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.250	LT 0.012	LT 0.016	LT 0.018	LT 0.012
08/04/91	AQ2FB	25	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.830	LT 0.012	LT 0.016	LT 0.018	LT 0.012
08/10/91	AQ3FB	40	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.194	LT 0.012	LT 0.016	LT 0.018	LT 0.012
08/16/91	AQ5FB	52	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.171	LT 0.012	LT 0.016	LT 0.018	LT 0.012
08/22/91	QI1FB	62	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.153	LT 0.012	LT 0.016	LT 0.018	LT 0.012
08/27/91	AQ2FB	66	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.138	LT 0.012	LT 0.016	LT 0.018	LT 0.012
08/28/91	QI2FB	30	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.171	LT 0.012	LT 0.016	LT 0.018	LT 0.012
09/03/91	AQ2FB	79	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	0.196	LT 0.012	LT 0.016	LT 0.018	LT 0.012
09/09/91	FC1FB	89	LT 0.023	LT 0.036	LT 0.012	LT 0.012	LT 0.012	LT 0.251	LT 0.012	LT 0.016	LT 0.018	LT 0.012
09/15/91	AQ3FB	93	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149
09/21/91	FC2FB	106	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149
09/27/91	AQ5FB	116	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149
		Minimum	0.023	0.036	0.012	0.012	0.012	0.090	0.012	0.016	0.018	0.012
		Maximum	0.149	0.149	0.149	0.149	0.149	0.830	0.149	0.149	0.149	0.149
		Average	0.034	0.044	0.021	0.021	0.021	0.238	0.021	0.025	0.027	0.021

LEGEND:

111TCE	1,1,1-Trichloroethane
112TCE	1,1,2-Trichloroethane
11DCLE	1,1-Dichloroethane
12DCE	trans-1,2-Dichloroethene
12DCLE	1,2-Dichloroethane
4BFB	Bromofluorobenzene (surrogate compound)
BCHPD	Bicycloheptadiene
C6H6	Benzene
CCL4	Carbon Tetrachloride
CHCL3	Chloroform

Table 8.3-1 CMP Target Volatile Organic Compounds (VOC) Blank Values (in ug) (continued)

Date	Site	Tag #	CLC6H5	DCPD	DMDS	ETC6H5	MEC6D8	MEC6H5	MIBK	TCLEE	TRCLE	XYLENE
01/23/91	FC5FB	9	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.229	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
01/29/91	FC5FB	18	LT 0.013	LT 0.089	LT 0.047	0.266	0.153	0.349	LT 0.160	LT 0.013	LT 0.013	1.330
02/04/91	AQ5FB	27	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.159	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
02/10/91	AQ5FB	36	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.134	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
02/22/91	AQ5FB	53	LT 0.013	LT 0.089	LT 0.047	0.165	0.153	0.991	LT 0.160	0.033	LT 0.013	0.746
02/28/91	AQ5FB	62	LT 0.013	LT 0.089	LT 0.047	0.066	0.190	0.578	LT 0.160	LT 0.013	LT 0.013	0.307
03/06/91	AQ5FB	72	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.190	0.183	LT 0.160	LT 0.013	LT 0.013	LT 0.149
03/12/91	AQ3FB	82	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.199	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
03/18/91	FC1FB	92	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.189	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
03/24/91	FC2FB	101	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.192	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
03/30/91	FC2FB	112	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.200	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
04/05/91	FC5FB	122	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.205	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
04/11/91	Q11FB	132	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.243	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
04/17/91	AQ2FB	142	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.201	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
04/23/91	FC1FB	152	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.172	0.154	LT 0.160	LT 0.013	0.111	LT 0.149
04/29/91	AQ3FB	164	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.278	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
05/05/91	AQ2FB	175	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.270	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
05/11/91	FC5FB	195	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.176	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
05/17/91	AQ2FB	205	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.361	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
05/23/91	AQ3FB	218	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.176	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
06/04/91	FC2FB	238	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.198	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
06/10/91	FC1FB	248	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.239	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
06/12/91	FC1FB	258	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.201	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
06/16/91	FC1FB	270	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.211	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
06/20/91	COMBS	276	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.425	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
06/20/91	Q11FB	286	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.208	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
06/22/91	FC5FB	296	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.204	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
06/26/91	AQ10FB	306	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.172	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
06/28/91	FC1FB	316	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.199	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
07/04/91	Q11FB	326	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.151	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
07/10/91	Q12FB	338	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.155	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
07/16/91	AQ3FB	348	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.225	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
07/22/91	FC1FB	358	LT 0.013	LT 0.089	LT 0.047	LT 0.032	LT 0.024	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
07/29/91	Q12FB	10	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.201	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
08/04/91	AQ2FB	25	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.070	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
08/10/91	AQ3FB	40	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.213	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
08/16/91	AQ5FB	52	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.208	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
08/22/91	Q11FB	62	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.165	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
08/27/91	AQ2FB	66	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.199	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
08/28/91	Q12FB	30	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.224	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
09/03/91	AQ2FB	79	LT 0.013	LT 0.089	LT 0.047	LT 0.032	0.153	0.041	LT 0.160	LT 0.013	LT 0.013	LT 0.149
09/09/91	FC1FB	89	LT 0.013	LT 0.089	LT 0.047	LT 0.032	LT 0.254	LT 0.014	LT 0.160	LT 0.013	LT 0.013	LT 0.149
09/15/91	AQ3FB	93	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149
09/21/91	FC2FB	106	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149
09/27/91	AQ5FB	116	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149	LT 0.149
			0.013	0.089	0.047	0.032	0.024	0.014	0.149	0.013	0.013	0.149
			0.149	0.149	0.149	0.266	0.425	0.991	0.160	0.149	0.149	1.330
			0.022	0.093	0.054	0.049	0.196	0.072	0.159	0.023	0.024	0.192

LEGEND:

CLC6H5	Chlorobenzene
DCPD	Dicyclopentadiene
DMDS	Dimethyl Dusulfide
ETC6H5	Ethylbenzene
MEC8D8	Toluene-d8 (surrogate compound)
MEC6H5	Toluene
MIBK	Methyl Isobutyl Ketone
TCLEE	Tetrachloroethene
TRCLE	Trichloroethene
XYLENE	Total Xylenes

TABLE 8.3-2

SUMMARY OF OCP PERCENT RECOVERIES IN FIELD SPIKING EVENTS

Target Analyte	Event #1 Sample #1	Sample #2	Event #2	Average	Maximum
Aldrin	LT	LT	LT	LT	LT
Chlorodane	51.5	58.5	136	82	136
Dieldrin	89.5	97.5	93.5	93.5	97.5
Endrin	94.2	96.5	107	99.2	97.5
Isodrin	LT	LT	LT	LT	LT
PPDDE	84.9	86.7	87.9	86.5	87.9
PPDDT	91	97.5	91.2	93.2	97.5

Table 8.3-3 OCP Blank Values (in ug)

Date	Site	Tag #	ALDRN		CLDRN		DLDRN		ENDRN		ISODR		PPDDE		PPDDT	
01/12/91	FC2	28162	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
01/18/91	FC2	28168	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
01/24/91	CFC5	109-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
01/30/91	CFC5	119-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
02/05/91	CAQ5	129-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
02/11/91	CAQ5	138-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
02/17/91	CAQ5	148-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
02/23/91	CAQ5	157-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
03/01/91	CAQ5	167-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
03/07/91	CAQ5	177-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
03/13/91	CAQ3	188-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
03/19/91	CFC1	198-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
03/25/91	CFC2	209-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
03/31/91	CFC2	220-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
04/18/91	CAQ2	252-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
04/24/91	CFC1	262-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
04/30/91	CQI3	275-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
05/06/91	CAQ2	285-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
05/12/91	CFC5	306-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
05/18/91	CAQ2	317-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
05/24/91	CAQ3	330-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
06/11/91	CFC1	363-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
06/13/91	CFC1	370-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
06/17/91	CFC1	382-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
06/21/91	CQI1	395-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
06/27/91	CAQ01078	406-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
06/29/91	CFC1	414-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
07/05/91	CQI1	432-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
07/11/91	CAQI2	445-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
07/17/91	CAQ3	455-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
07/23/91	CFC1	463-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
07/29/91	CQI2	1-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
08/04/91	CAQ2	18-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
08/10/91	CAQ3	33-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
08/16/91	CAQ5	44-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
08/22/91	CQI1	55-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
08/28/91	CQI2	70-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
08/30/91	CAQ2	60-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
09/03/91	CAQ2	76-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
09/19/91	CFC1	92-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
09/15/91	CAQ3	99-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
09/21/91	CFC2	104-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
09/27/91	CAQ5	127-P	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100	LT	0.100
		Maximum		0.100		0.100		0.100		0.100		0.100		0.100		0.100
		Minimum		0.100		0.100		0.100		0.100		0.100		0.100		0.100
		Average		0.100		0.100		0.100		0.100		0.100		0.100		0.100

LEGEND:
- ALDRN Aldrin
- CLDRN Chlordan
- DLDRN Dieldrn
- ENDRN Endrin
- ISODR Isodrin
- PPDDE Dichlorodiphenyldichloroethylene
- PPDDT Dichlorodiphenyltrichloroethane

Table 8.3-4

Metals Blank Values (in ug)

Date	Site	Filter Number	CADMIUM	CHROMIUM	COPPER	LEAD	ZINC	ARSENIC
01/24/91	CAQ1	Q772	LT 4.00	LT 20.00	LT 10.00	LT 40.00	25.80	LT 1.41
01/30/91	CAQ1	Q799	4.86	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
02/05/91	CAQ3	Q826	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
02/11/91	CAQ4	Q847	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
02/17/91	CAQ55	Q868	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
02/23/91	CAQ6	Q895	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
03/01/91	CAQ7	Q916	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
03/07/91	CAQ8	Q944	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
03/13/91	CAQ9	Q965	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
03/19/91	CAQ10	Q993	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
03/25/91	CAQ11	Q1017	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
03/31/91	CAQ12	Q1045	LT 4.00	LT 20.00		LT 40.00	LT 20.00	LT 1.41
04/06/91	CFC1	Q1074	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
04/16/91	CQI1	Q1108	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
04/18/91	CFC2	Q1134	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
04/24/91	CQI2	Q1166	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
04/30/91	CFC3	Q1192	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
05/06/91	CAQ1	Q1228	LT 4.00	LT 20.00	LT 10.00	LT 40.00	26.30	LT 1.41
05/12/91	CFC5	Q1249	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
05/18/91	CAQ2	Q1280						LT 1.41
05/24/91	CAQ3	Q1291						LT 1.41
05/30/91	CQI1	Q1336	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
06/05/91	CAQ4	Q1361	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
06/11/91	CAQ5	Q1391	LT 4.00	26.70	LT 10.00	LT 40.00	LT 20.00	LT 1.41
06/17/91	CAQ6	Q1423	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
06/23/91	CAQ7	Q1454	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
06/29/91	CAQ8	Q1483	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
07/03/91	CAQ25007	Q0001501	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
07/05/91	CAQ9	Q0000627	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
07/11/91	CQI2	Q0000662	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
07/17/91	CAQ10	Q0000695	LT 4.00	LT 20.00	33.00	LT 40.00	49.70	LT 1.41
07/23/91	CFC1	Q2026	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
07/29/91	CAQ1	Q1531	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
08/04/91	CAQ2	Q1562	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
08/10/91	CAQ3	Q1587	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
08/16/91	CAQ5	Q2064	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
08/23/91	CQI1	Q2089	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
08/29/91	CQI2	Q2118	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
09/03/91	CAQ8	Q0216	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
09/09/91	CFC1	Q0218	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
09/15/91	CAQ6	Q0261	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
09/21/91	CFC2	Q0299	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
09/27/91	CAQ7A-	Q0324	LT 4.00	LT 20.00	LT 10.00	LT 40.00	LT 20.00	LT 1.41
		Maximum	4.86	26.70	33.00	40.00	49.70	1.41
		Minimum	4.00	20.00	10.00	40.00	20.00	1.41
		Average	4.02	20.16	10.58	40.00	21.02	1.41

TABLE 8.3-5

TSP-PM10 FIELD BLANK VALUES
(in μg)

Date	Site	Filter Number	Sample Net Weight
1/24/91	AQ1FB	Q772	0
1/30/91	AQ2FB	Q799	0
2/05/91	AQ3FB	Q826	4700
2/11/91	AQ4FB	Q847	-2000
2/17/91	AQ5FB	Q868	4000
2/23/91	AQ6FB	Q895	0
3/01/91	AQ7FB	Q916	0
3/07/91	AQ8FB	Q944	0
3/13/91	AQ9FB	Q965	0
3/19/91	AQ10FB	Q993	1700
3/25/91	AQ11FB	Q1017	0
3/31/91	AQ12FB	Q1045	0
4/06/91	FC1FB	Q1074	0
4/12/91	QI1FB	Q1108	0
4/18/91	FC2FB	Q1134	0
4/24/91	QI2FB	Q1166	0
4/30/91	FC3FB	Q1192	0
5/06/91	AQ1FB	Q1228	800
5/12/91	FC5FB	Q1249	1400
5/18/91	AQ2FB	Q1280	1300
5/24/91	AQ3FB	Q1291	2800
5/30/91	QI1FB	Q1336	700
6/05/91	AQ4FB	Q1361	1700
6/11/91	AQ5FB	Q1391	1600

TABLE 8.3-5
(Concluded)

Date	Site	Filter Number	Sample Net Weight
6/17/91	AQ6FB	Q1423	600
6/23/91	AQ7FB	Q1454	1600
6/29/91	AQ8FB	Q1483	1700
7/02/91	MOB.E	Q1501	1900
7/05/91	AQ9FB	Q0000627	100
7/11/91	QI2FB	Q0000662	700
7/17/91	AQ10FB	Q0000695	1000
7/23/91	FC1FB	Q2026	100
7/29/91	AQ1FB	Q1531	800
8/04/91	AQ2FB	Q1562	3200
8/10/91	AQ3FB	Q1587	1400
8/16/91	AQ5FB	Q2064	0
8/23/91	QI1FB	Q2089	400
8/29/91	QI2FB	Q2118	100
9/04/91	AQ8FB	Q0216	0
9/09/91	FC1FB	Q0218	0
9/16/91	AQ6FB	Q0261	0
9/22/91	FC2FB	Q0299	0
9/28/91	AQ7FB	Q0324	0
Maximum			4700
Minimum			0
Average			751

TABLE 8.4-1
COLLOCATED SAMPLE COMPARISONS FOR FY91

Target Compound	# Pairs	# > LCRL*	Average Percent Difference
TSP	37	2	-9.90
PM-10	38	22	-0.74
Cadmium	18	18	----
Chromium	18	18	----
Copper	15	0	100.63
Lead	18	16	-8.90
Zinc	16	2	-2.47
Arsenic	18	17	-0.95
VOC**			
1,1,1-Trichloroethane	44	3	23.88
1,1,2-Trichloroethane	44	44	----
1,1-Dichloroethane	44	44	----
trans-1,2-Dichloroethene	44	44	----
1,2-Dichloroethane	44	41	56.58
Bicycloheptadiene	44	44	----
Benzene	44	2	34.40
Carbon Tetrachloride	44	3	17.34
Chloroform	43	13	3.33
Chlorobenzene	44	43	6.43
Dicyclopentadiene	44	44	----
Dimethyl Disulfide	44	44	----
Ethylbenzene	44	17	46.94
Toluene	44	14	130.61
Methyl Isobutyl Ketone	44	44	----
Tetrachloroethene	44	8	43.01
Trichloroethene	44	42	-15.72
Total Xylenes	44	44	----
OCP			
ALdrin	41	37	53.63
Chlordane	41	26	-13.35
Dieldrin	41	9	55.15
Endrin	41	27	-36.16
Isodrin	41	41	----
PPDDE	41	40	-3.91
PPDDT	41	40	0.55

* For TSP and PM-10, LCRL refers to 20 ug/m3, as ther is no LCRL.

** For VOCs, precision calculations were based on all observations, including those above as well as within certified reporting limits

(S) Compound is a lab surrogate.

Legend: PPDDE = Dichlorodiphenyldichloroethylene

PPDDT = Dichlorodiphenyltrichloroethane

TABLE 8.4-2

CONTINUOUS AIR QUALITY PARAMETERS PRECISION RESULTS

Parameter	Average Percent Difference
Ozone	-0.11
Carbon Monoxide	-5.57
Sulfur Dioxide	-3.01
Nitrogen Oxides	-3.49

9.0
CONCLUSIONS

This report focuses on results of the CMP for FY91 and includes analyses and comparisons to data for preceding monitoring programs at RMA and for other programs which ran concurrently. The data were used to characterize the air quality at RMA and also to describe both the impacts of Basin F remedial activities and the cessation of those activities.

Analyses of these data were used to characterize potential sources for air contaminants which were observed, including both RMA and metropolitan Denver influences. On-site meteorological data were also used to describe those conditions associated with the average and the extreme events. Dispersion modeling was used to evaluate potential sources.

The FY91 program continued the ambient air monitoring for similar compounds which were sampled during the FY88, FY89, and FY90 programs. These compounds include total suspended particulates, PM-10, asbestos, volatile organic compounds, organochlorine pesticides, mercury, arsenic, and other metals. Sampling for the complete suite of semi-volatile organic compounds was discontinued and limited to the organochlorine pesticides only during FY91. The following discussion summarizes the results of the analyses for each group of air quality parameters.

9.1 TOTAL SUSPENDED PARTICULATES

TSP levels at RMA can be attributed to two principal sources: (1) the influx of particulates from metropolitan Denver, and (2) remedial activity sources which helped to produce wind-blown dust, particularly during very dry episodes. Intense remedial activity was initiated during FY88 and continued into FY89. These activities were concluded in several steps, including the completion of intrusive activities (December 12), the completion of the development of the clay caps (February 15), and the completion of all topsoil remediation activities (May 5). The TSP data clearly reflect the impact of these activities, with dramatic decreases in TSP levels around Basin F and

throughout the Arsenal. After the conclusion of remedial activities and surface disturbance activities on Basin F had ceased, TSP concentrations monitored in vicinity of Basin F decreased significantly and maintained similar concentration distributions during FY90 and FY91. During the height of the Basin F activities, the TSP levels which could be attributed to remediation activities also decreased significantly with distance from the basin or activity source. This feature was observed in the FY88 through FY91 data with respect to Basin F activities and other localized remediation work. In addition, there were several episodes during which impacts from metropolitan Denver completely overwhelmed impacts from potential on-site sources. At the eastern and northern boundaries of RMA, the TSP levels were well below those of metropolitan Denver, and were more representative of rural conditions.

9.2 RESPIRABLE PARTICULATES (PM-10)

Respirable particulates are generated by dry windy conditions, but to a much lesser extent than for TSP. There were no violations of the annual or 24-hour PM-10 standards at RMA during FY91. During the post-remedial phases, there were some increases in PM-10 levels immediately adjacent to surface disturbance activities as a result of construction or other intrusive operations; however, these impacts were highly localized and concentrations decreased significantly at short distances from the potential source. Generally, variations in PM-10 concentrations during FY90 and FY91 appeared to be most dependent upon regional influences from metropolitan Denver.

9.3 METALS

Ambient concentrations of metals across RMA were generally proportional to levels of TSP. Maximum concentrations were sampled on high wind speed days and also when there were high TSP and PM-10 levels, that were frequently attributable to sources off the Arsenal. During remediation activities, Basin F appeared to be a source of mercury, chromium, copper and zinc, and these concentrations decreased rapidly with distance from Basin F. Following remediation of Basin F, the metals concentrations were reduced to those typical of baseline conditions. During FY89, there were several instances of high metals concentrations associated with low wind speeds and strong inversion conditions, with a likely source in the Denver metropolitan area. Isolated

concentration maxima of chromium, cadmium and copper, relative to average post-remedial concentrations, were measured during FY91 which did not appear to be directly attributable to RMA sources.

9.4 ASBESTOS

Asbestos was detected twice at RMA during FY91 at sites AQ6 and AQ8 on the same sampling date. No detections of asbestos occurred during FY88 and FY90, and only 2 days with detections occurred during FY89. These results confirm that there is no evident source of ambient asbestos fibers on RMA.

9.5 VOLATILE ORGANIC COMPOUNDS

During the Basin F remediation, on-site activities appeared to be a source of several volatile organic compounds, including bicycloheptadiene, dimethyl disulfide, benzene, toluene, and ethylbenzene. The sources of these compounds could have resulted from the emissions from heavy equipment which was used during remediation. Chloroform was identified near both Basin F and the South Plants. Levels of VOCs which were attributed to RMA sources during the Basin F remediation period decreased rapidly with distance from those sources, and levels at RMA boundaries were similar to or less than those within the urban environment of metropolitan Denver. During FY89, FY90, and FY91 monitored concentrations of many of the VOCs attributed to Basin F decreased significantly. During FY91, most of the VOC concentrations measured at RMA monitoring sites were attributed to close-by off-Arsenal sources, since observed VOC concentration distributions did not conform to those expected when a RMA source is the primary influence.

9.6 SEMI-VOLATILE ORGANIC COMPOUNDS

Basin F appeared to be a source of several semi-volatile organic compounds, including aldrin, dieldrin, and endrin during the Basin F remediation activity period. The highest levels were detected in the immediate vicinity of Basin F during these remediation efforts. Results from BF2, at the northeast perimeter of Basin F, showed the highest levels of SVOCs, but at the RMA boundaries, these levels were reduced to roughly

background levels. During the FY89 and FY90 post-remedial periods, SVOC concentrations were reduced significantly in the vicinity of Basin F and all SVOC concentrations at other RMA (CMP) monitoring sites were close to background levels. With the decrease of most SVOC concentrations to background levels, the monitoring of SVOCs was limited to the OCP sub-set during FY91. Thus, SVOC sampling during FY91 consisted of the OCPs only and were exclusively analyzed in the laboratory by the more sensitive method designed to detect lower concentrations.

9.7 ORGANOCHLORINE PESTICIDES

During FY90, these compounds were at or near the detection limit at the RMA boundary sites. Highest levels were sampled during the Basin F remediation effort, and nearest to Basin F itself. Following the completion of the remedial activities, these levels were reduced to near background levels in the vicinity of Basin F as well. Highest OCP concentrations during FY90 and FY91 were measured at AQ3, suggesting a primary source north of RMA with potentially minor impacts from Basin F based on prevailing wind patterns.

9.8 CRITERIA POLLUTANTS

Ambient concentrations of the criteria pollutants, including sulfur dioxide, nitrogen dioxide, carbon monoxide, and ozone were monitored continuously at RMA during FY91. Generally, the air quality at the RMA monitoring location was cleaner than at other sites in the Denver area. Criteria pollutant concentrations monitored within RMA showed no violations of any applicable short-term or long-term standards. Episodes with relatively high concentrations at RMA were related to potential nearby sources under certain meteorological conditions. Most occurrences of relatively higher ambient concentrations within RMA appeared to be attributable to metropolitan Denver influences.

9.9 GENERAL INTERPRETATIONS

All data reported in this report must be interpreted with due consideration of the distributions observed within all air quality and meteorological parameters monitored

the CAQMMP. Additional factors influencing parameter distributions include sampling frequency, analysis limitations, and a limited observation period. Interpretations must also consider any anomalous meteorological (air quality) conditions as well as possible influences of metropolitan Denver sources on RMA ambient air quality. As more data are collected under subsequent monitoring programs, these conclusions may need to be refined and reinterpreted.

10.0
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